MACRO-ECONOMIC FACTORS FOR ENHANCING CONSTRUCTION OUTPUT AND POLICY FORMULATION IN KENYA

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Macro-Economic Factors for Enhancing Construction Output and Policy Formulation in Kenya

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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This thesis has been submitted for examination with our approval as university supervisors.

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DEDICATION

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ABBREVIATIONS AND ACRONYMS

AIC	-	Advanced Industrialized Countries
AR	-	Autoregressive
ARIMA	-	Autoregressive Integrated Moving Average
CBK	-	Central Bank of Kenya
CBR	-	Central Bank Rate
CIDAC	-	Construction Industry Development Advisory Committee
CPI	-	Consumer Price Index
ERS	-	Economic Recovery Strategy
GDP	-	Gross Domestic Product
KNBS	-	Kenya National Bureau of Statistics
LAPSSET	-	Lamu Port Southern Sudan Ethiopia
LDC	-	Less Developed Countries
MA	-	Moving Average
MAPE	-	Mean Absolute Percentage Error
MOPW	-	Ministry of Public Works
MPC	-	Monetary Policy Committee
MTP	-	Medium Term Plan

MR	**-**	Multiple Regressions
NCA	-	National Construction Authority
NIC	**-**	Newly Industrialized Countries
RMSE	-	Root Mean Square Error
SGR	-	Standard Gauge Railway
SIC	**-**	Standard Industrial Classification
SNA	-	System of National Accounting
VAR	-	Vector Autoregression
VECM	-	Vector Error Correction Model

ABSTRACT

Management of construction industry at the micro level is currently a problem in Kenya. This happens in three dimensions: construction demand estimation, construction supply targeting and construction output control in the country. This inefficiency in the management of construction industry has resulted in a number of policy failures regarding the industry and its performance. This report presents a research study on the impact of macro-economic factors on the annual construction output in Kenya, in a bid to address this inefficiency in the macro management of construction industry. The study objectives were: analysis of the trends of construction output and the macro - economic factors, establish relationship between macroeconomic factors and construction output and to establish the way past levels of construction output have been influencing present levels over the period of forty-three (43) years. The variables were: annual construction output, inflation rate, unemployment rate, commercial banks weighted interest rate, population growth rate and US dollar to Kenya shilling exchange rate. Time series data analysis methods were used to analyze data which were obtained from Central Bank of Kenya (CBK) and the Kenya National Bureau of Statistics (KNBS) covering forty-three (43) years; from 1977 to 2019. Eviews for windows version 10; a computer software package, was used to analyze the data. Observations from multiple regression output tables of current macro-economic variables showed insignificant influence of macro-economic factors on annual construction output in Kenya in the current year. It was however noticed from regression of lagged macro-economic values that construction output in Kenya responds to the effects of the factors more than a year after they are implemented. Models to this effect have been developed having coefficients of determination (R^2) values of 0.13 and 0.48 respectively. Nonlinear regression results of annual construction output and the macro-economic factors were not significant. However dynamic regression modeling of construction output in Kenya which was as a result of co-integration amongst the variables gave reliable and encouraging results. The coefficient of determination (R^2) of the dynamic model was 0.92. A number of vigorous tests were carried out to check/show the reliability of the dynamic model. It was however found that, the model was limited in its application due to the condition of integration of order one (I/1). ARIMA modeling of construction output produced encouraging and reliable results as well. ARIMA (0,1,0) was modeled for annual construction output in Kenya which showed that construction output in the current year depended on the output of the past one year. The developed ARIMA model was evaluated on its predictive power on the basis of an out-of-sample forecast. Therefore, the two adopted measures of accuracy; namely MAPE and RMSE produced fairly good results and hence, the model can be used for forecasting construction output in Kenya. Based on the results obtained, conclusions are drawn that macro –economic factors can be used in managing Kenya's construction industry as effective policy instruments.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Globally, construction industry is viewed as a key industry in the growth of any economy. Take for example in the UK where in 1991 the industry directly employed 1.2 million people (Ive & Gruneberg, 2000). This number excludes those employed by manufacturers of some different types of building construction components such as cement and the self-employed in the industry (Ive & Gruneberg, 2000). Therefore, given that provision of employment is just one aspect of the many roles played by the industry in the global economy, its importance in this perspective cannot be overemphasized. It is therefore very clear that this industry plays multiple roles in all global economies and can be viewed as a key component of every specific economy of the world. The foregoing information is now acting as a pointer towards the need for interrogation about what might retard the growth of construction industry from the perspective of macroeconomic factors.

The centrality of construction industry in any economy is further demonstrated by viewing its role in Germany. In Janssen, (1983) as cited in Ive & Gruneberg, (2000) shows the contribution of the construction industry in the economy of Germany in respect to employment opportunities. Therefore, according to them, the number of employees engaged directly by the industry in the country as at 1980 was 4.6 million (Janssen, 1983). This trend is observable in many other world countries which is a pointer of the critical role played by construction industry over and above provision of constructed facilities in any country.

In theory, demand for constructed facilities in Africa is expected to be high. The reason behind this being that the continent comprises of third world countries where the need for goods supplied by the industry is on the rise (Bon, 1992). This scenario is mostly due to a number of reasons which include fast growing population and growing need for infrastructure to support the continent's economy.

In regard to Gross National Product of world countries, first world countries are leading in the share of construction output. It is estimated that first world countries account for 78% share of the world construction output while Africa and Oceania and other such regions account for only 2%. This was reported by Davis Langdon Consultancy (Hillebrandt, 2000). It is therefore clear from these statistics that Africa needs to do more to meet the demand for constructed facilities which is constantly rising.

A view of local perspective of the industry in Kenya shows that construction industry is a major contributor to the country's Gross Domestic Product (GDP). This essentially implies that the industry is a very indispensable component to the economic development of the country. Further, in support of this notion, it is seen in Kenya National Bureau of Statistics - KNBS, (2015), that the sector's contribution to the GDP was 11.1% in 2014. It was ranked in the second position amongst the main sectors driving the country's economy by 13.1% in the same year (KNBS, 2015). In the following year, 2015, the sector grew by 13.6% as indicated in (KNBS, 2016). However, this sector decelerated in growth according to KNBS, (2017) to 9.2% in 2016. This deceleration translates to 4.4% as compared to the sector's growth in 2015. This deceleration continued to persist since in the following years; 2017 and 2018 the industry recorded a growth of 8.5% and 6.3% respectively (KNBS, 2019). Therefore, this information is a clear indication of the slow growth and excessive fluctuations in growth of the industry and hence calls for an empirical inquiry as regards to whether the macroeconomic factors have any influence on construction output levels in Kenya.

Apart from the sector's contribution to the GDP, it also contributes to offering solutions to two macro-economic problems which the country is currently grappling with, namely: housing and unemployment. According to the National Housing Policy, (2004)**,** inadequacy in housing provision to the country's ever-growing population is seen as a major problem to this country. Interesting enough is that construction industry, while providing a solution to the housing crunch, it also provides employment to the unemployed. Taking the year 2015, for example, the construction sector employed 148,000 people up from 132,900 people it employed in 2014 (KNBS, 2016). As a clear importance of the role this industry is playing in this respect, the employment volume into the industry continued to swell from the 148,000 in 2015 to 163,000 in 2016. The annual economic survey reported this information (KNBS, 2017). Further, it is also observed in KNBS, (2018) that the industry employed 167,900 people in 2017. In the following year, this number increased by 2.2% and reached 171.6 thousand people (KNBS, 2019). It is therefore, clearly seen from the foregoing that, the industry's role in job creation is very central. This is a dual importance of the industry and further justifies the emphasis for the need to establish the empirical relationships between the quantities of construction output and the variables that influence them.

Estimates of the housing need and projections of production targets have variously been made. According to the National Housing Policy, (2004), housing demand was estimated at 7,600 housing units in urban areas and 38,000 housing units in the rural areas every single year. In this regard, the government undertook this policy, to provide 150,000 housing units every year in the urban areas and 300,000 housing units every year in the rural areas (National Housing Policy, 2004). This is yet to be achieved and it is now about fourteen years down the line since the development of the national housing policy. This scenario implies errors of targeting in the housing demand and supply side of the economy.

In Kenya's vision 2030, which is the country's long-term economic development blue-print, it is seen that, a number of projects and mainly those to be delivered by the construction industry are progressing at a very slow pace and others are yet to take off. Take for instance, the Standard Gauge Railway (SGR). The initial plan of doing 1,500 kilometres-long railways from Mombasa to Kigali was expected to reach completion by 2018, but so far the project is still ongoing coupled with numerous time overruns. Other projects include Konza Techno-City and the Lamu – Port, Southern Sudan, Ethiopia Project which is generally known as (LAPSSET). Once these projects are completed, they shall form part of construction output which is expected to push the economy to great heights of success since its growth behavior is paramount and more so, due to its multiplier effect which makes it even a more indispensable ingredient of the economy (Akintoye & Skitmore, 1991). Therefore, it is quite important to establish the factors that have influence on its growth and hence increase its contribution to the GDP.

The growth of construction industry is very oscillatory and quite low in many cases. According to economic surveys of the country from 2003 up to 2007, the growth of the industry has been very slow. In 2003 the industry growth was 3%, in 2004 it was 3.5% and the highest was recorded in 2007; a value of 7.3% for the five (5) year period. For the period beginning in 2008 up to 2012; the period for the vision's medium-term plan, the growth rate was 8.2%, 12.7%, 4.5%, 4.3% and 11.3% respectively. The same trend continued from 2013 to 2018 which indicated growth of 5.8%, 13.1%, 13.6%, 9.2%, 8.5% and 6.3%. As it can be observed, this growth rate of the industry is very slow, low and it is fluctuating a lot. Therefore, a lot is desired in regard to its growth behavior and hence the reason for this research. Table 1.1 below shows the growth rates of the construction industry from 2003 to 2018.

Table 1.1: Growth of the Construction Industry of Kenya

Year	Growth Rate (%)	Contribution to GDP (%)
2003	3	1.1
2004	3.5	2.6
2005	7.2	3.8
2006	6.3	3
2007	6.9	3.8
2008	8.2	3.8
2009	12.7	4.1
2010	4.5	4.3
2011	4.3	4.1
2012	11.3	13.1
2013	5.8	5.8
2014	13.1	4.9
2015	13.6	4.9
2016	9.2	5.1
2017	8.3	5.6
2018	6.3	5.4

Source: KNBS, (2003 – 2018)

A number of economic factors do have positive or negative impact on Kenya's construction industry output levels. From the Economic Survey Reports of Kenya, (KNBS 2003 – 2018), Kivaa, (2008) and anecdotal evidence (for example, Mwaniki, 2018 and Macharia, 2015) a great variety of the determinants of construction demand can be gleaned. These factors include fiscal policy factors such as taxation and the government's expenditure on construction, and monetary policy factors which include interest rates, exchange rate and inflation rate. Other key macro-economic factors influencing construction activity in Kenya include the unemployment/employment rate, population growth. Influences of these factors are not unique to Kenya. Similar factors are reported to have influenced construction output in other world economies, as highlighted in Akintoye & Skitmore, (1994) and Bee Hua, (1996). These factors have over the years impacted the construction industry in diverse ways noteworthy mentioning that most of the funds expended in this industry are usually borrowed

(Akintoye & Sommerville, 1995). This scenario cannot be overemphasized since it is universally acceptable that developers use borrowed funds to finance their construction projects due to the colossal amounts involved (Gruneberg, 1997) and (Myers, 2008).

Construction industry of Kenya is not an exception in the utilization of borrowed funds. This is exhibited, for example in KNBS, (2015), where it is reported that commercial banks in Kenya extended credit to the sector of Kshs. 70.8 billion in 2013 and 80.4 billion in 2014. This translates to a credit increase of 13.6% that year. Consequently, credit advanced to the construction sector went up by 32.3% escalating from Kshs. 80.4 billion to Kshs 106.4 billion in 2015 (KNBS, 2016). However, this lending to the construction industry dropped to Kshs. 104.8 billion in 2016 as seen in KNBS, (2017) and went up once more to Kshs. 111.99 billion in 2017 and Kshs. 114.02 billion (KNBS, 2018) and (KNBS, 2019). It has also been pointed out that building and construction is among the sectors whose demand for credit remained unchanged in the third quarter of 2017 (Mwaniki, 2018). This is confirmed by looking at the share of credit extended by commercial banks to the industry from 2014 to 2018 which is 3.3%, 3.7%, 3.4%, 3.3% and 3.2% respectively (KNBS, 2019). Such fluctuations in the credit availed to the industry are likely to impact on the construction output (supply) and/or orders (demand).

In the Kenya Vision 2030, it is clearly stated that the government will build on the successes made under Economic Recovery Strategy (ERS) while pursuing a macroeconomic framework that will be able to facilitate a low and stable inflation rate, interest rates, and a sustainable public sector debt position. A competitive real exchange rate, which will support an export-led economic growth and facilitate the economy to deliver high and sustainable levels of growth including employment and poverty reduction is also emphasized in the document (Ministry of Planning, 2007). The indication here is that the government is experiencing the impact of macro-economic factors on the economy while a sustained growth of construction industry is likely to help in reduction of some of the negative impacts.

1.2 Statement of the Problem

Management of construction industry at the macro level remains a problem in Kenya today. According to Kivaa, (2008) and Odunga, (2017) construction demand estimation, construction supply targeting and construction output control remain hard nuts to crack in the country. In a market economy like Kenya, construction demand and supply are left for market forces. However, in view of the adversity of excessive fluctuations in construction supply in the country, there is need for more imaginative and proactive initiatives to effectively manage the construction market at the macro-level (Kivaa, 2008). This is achievable through establishing first the influence of macroeconomic factors on Kenya's construction output.

Managerial effectiveness and efficiency at macro and micro levels would be a great thing for the construction industry of Kenya. Inefficiency in the management of construction industry has resulted in several policy failures. A good example is the estimation of housing demand and growth rates thereof in the National Housing Policy of Kenya (2004). In this policy, housing demand growth rate was estimated at 7600 units per year. However, according to Odunga, (2017), this figure was too low to represent the reality on the ground. In addition, the Comptroller's HandBook (2013) and Gransberg et al, (2006), say that macro-economic factors are major in making a decision to build or purchase construction plant and equipment due to their impact. However, the magnitude of their influence is not well specified. Therefore, while focusing on the impediments of constructed facilities supply targets in the country, relationship between construction output and macro-economic factors in Kenya should be established. In practice, that relationship is normally expressed in qualitative and heuristic terms which are often inaccurate (Myers, 2008). Therefore, there is need for an empirical study to establish the actual situation in Kenya.

This state of affairs makes policy design and implementation for the growth and development of the construction industry very challenging. What has been observed so far is that the construction output targets for built facilities in the policies are considerably greater than the actual production capacity of the industry (KNBS, 2018 and World Bank, 2017). Such errors of demand estimating and production targeting are indicative of unrealistic industry policy.

Three examples of policies that have failed due to this situation are the Housing Policy, Vision 2030 and the Big Four Agenda. These are amplified as follows: -

1) *National Housing Policy*. This policy was formulated fifteen years ago. Its aim was to ensure the demand for housing which was 7,600 units per year was met by providing 150, 000 units per year in the urban areas. Today, this remains a farfetched dream as observed in the millennium development goals (Ministry of Planning, 2007) and Vision 2030.

   Currently, this demand has since risen to 200,000 housing units per year in the urban areas (Odunga, 2017). Therefore, it is clear that the housing problem in the country is growing bigger by the day and the construction industry is practically unable to meet the demand. The situation is even aggravated by the current high rate of population growth which has hit 53 million people as at the beginning of April, 2020 (Worldometer, 2020). This is a clear indication that Kenya's population is still growing at a fairly high rate and hence the housing demand.

2) *Vision 2030*. It initially used to be vision 2020 but later changed to vision 2030 due to foreseeable reasons that its goals were not achievable. In the Vision 2030, one of the flagship projects is the provision of 200,000 housing units through a mixture of initiatives (Ministry of Planning, 2007). As highlighted in the Medium-Term Plan, (MTP) the 200,000 units were to be done every single year from 2008 to 2012, but a World Bank (2017) report, states that only less than 50,000 housing units are realized every single year. Other flagship projects under the Vision 2030 are:

- Standard Gauge Railway (SGR): This was expected to reach Kigali Rwanda in 2018. So far, this project is still ongoing with protracted time overruns.
- Konza Technopolis: Slowly coming up. The horizontal infrastructure was expected to be completed by 2021 but later moved to middle of 2022. This still remains a wait and see situation.
- LAPSSET: The construction contract for first three berths was signed on 1st August, 2014. It is purely financed by Kenya government and the first berth was expected to be completed by 2018 and the remaining two berths to be completed by 2020. This first berth experienced some delays and the reason given was lack of funds.

3) *The Big Four Agenda*. This includes food security, affordable housing, manufacturing and universal healthcare. Under this initiative, affordable housing target is 500,000 housing units spread over a period of five years. This translates to 100,000 housing units in a single year. In order to actualize this plan, the government intended to:

   i) Decrease costs of mortgages
   ii) Use innovative technologies and materials to bring down cost of construction.
   iii) Invest in large-scale housing construction project using low-cost funds raised from private and public sector (KEPSA, 2017)**.**

These targets and policy actions remain elusive in Kenya today. From the foregoing, it is clear that the construction industry of Kenya has so far not been effectively satisfying the country's demand for constructed facilities. This calls for refinement of the policies described above and/or boosting growth of the industry's production capacity. One way of achieving this is to first establish the empirical influence of macro-economic variables on the construction activity in the country.

Ideally, construction industry of Kenya should be able to meet the construction demand for the country, by supplying all the constructed facilities required in the country. It is further expected that the industry maintains a steady growth and stable workload. This has not been happening and it is the matter which motivated the researcher to undertake this study.

1.3 Aim and Objectives of the Study

The aim of the research is to investigate the influence of macro-economic factors on construction demand and supply in Kenya. In this study, construction output is used as the proxy for construction supply and demand as has been done in previous studies, for example Akintoye and Skitmore (1994), Kivaa, (2008) and Notman et al, (1998). Accordingly, the study seeks to establish the influence that the macroeconomic variables have on construction output in Kenya, for the purpose of enhancing accuracy in the explanation of changes in the output, and enhancement of policy design and implementation for the growth and development of the industry.

The specific objectives are:

1. To analyze the trends of construction output and the macro - economic factors that affect it in Kenya.
2. To find out the relationship between construction output and the macroeconomic factors that have been influencing it in Kenya over a period of forty-three (43) years – from 1977 to 2019.
3. To establish the way past levels of construction output have been influencing present levels over the period of forty-three (43) years.

The macro-economic factors affecting annual construction output levels in diverse ways are:

1. Unemployment rate in Kenya,
2. Population growth rate in Kenya,

3. Commercial banks weighted interest rates in Kenya,
4. Inflation rate in Kenya, and finally
5. Exchange rate (Kenya shilling to US Dollar)

The five (5) factors are considered in the data analysis and hypothesis testing in each of the objectives. The factors are amplified in chapter II later in the report.

1.4 Hypothesis of the Study

Construction output levels in Kenya are influenced by macro-economic factors in the country. As earlier stated, the factors include: Unemployment rate, Population growth rate, rates of interest, rates of inflation and rates of currency exchange.

This hypothesis is tested through the standard time series multiple regression model: -

General Regression Model

$$\mathbf{Y = \alpha + \sum \beta_1 X_t + \varepsilon_t}$$

Where,

Y = Dependent variable

α = Intercept

β_1 = Slope Coefficient

ε_t = Disturbance or error term

α and β_1 are also known as parameters of the model (Gujarati & Porter, 2009)

In this study, regression analysis is carried out applying the standard time series multiple regression model to construction activity and the following regression equation is formulated: -

$$CO_t = \alpha + \beta_1 CBWR_t + \beta_2 IR_t + \beta_3 ER_t + \beta_4 UNEMPR_t + \beta_5 POPGR_t + \varepsilon_t$$

Where:

CO_t = Construction Output in a specific year

$CBWR_t$ = Weighted Interest Rates of Commercial Banks in a specific year

IR_t = Inflation Rates in a specific year

ER_t = Exchange Rate of Kenya shilling per US dollar in a specific year

$UNEMPR_t$ = Unemployment rate at any specific year

$POPGR_t$ = Population growth rate at a specific year

α = Intercept - the CO_t value when independent variables are zero rated

β_i = Regression Coefficient

ε_t = Error Term or Residual

The research hypothesis in this study is that construction output levels are influenced by macro-economic factors in Kenya. Therefore, the research hypothesis (H_1) is expressed mathematically in the study as $\beta_i \neq 0$ for at least one coefficient of regression, and the null hypothesis is taken as (H_0) such that $\beta_i = 0$ for all the regression coefficients.

Therefore, the null hypothesis can be stated as follows:

H_0: Construction output levels in Kenya are not influenced by macro-economic factors in Kenya.

1.5 Significance of the Study

The research problem addressed here in this study is the challenges faced by the government in effectively addressing construction industry's slow and fluctuating growth behavior and hence failing to meet the country's demand for constructed facilities as stated in various policy guidelines.

It can be clearly seen that the stunted growth of the construction sector in Kenya is attributable to knowledge limitation with regard to the empirical relationship between construction sector's output growth and the leading macro-economic factors that influence it in Kenya. The named macro-economic factors as it were, have neither been keenly researched nor investigated.

Emanating from this study, experts including players in Kenya's construction industry are really going to comprehend the impacts that the macro-economic factors have on construction projects/the sector in general and consequently being able to adequately address them for smooth project management from inception to completion. It is also going to aid in accuracy in policy design which is undeniably going to make a major step forward in the country's economy in addition to the construction industry in specific terms.

1.6 Justification of the Study

It has been seen in various reports especially those compiled by KNBS (Kenya National Bureau of Statistics); Kenya Facts and Figures and Economic Surveys from 2003 up to

2018, that the industry's growth has been very slow and fluctuating a lot. This fluctuation is also attested to in Kivaa, (2008). Another report from the MOW (Ministry of Public Works) which is dated 2005, indicates that, towards end of 2002, public building projects amounting to 197 had stalled. The projects are scattered all over the country. From this number, 43.7% of these projects which had stalled were hospitals and health centers which are bound to pose a huge social impact on the country's people. This report from the Ministry of Public works continued to show that as much as the Kenya's government delved on a very serious plan for completing the projects which had stalled, an increasing number continued to stall. By the end of 2008, a whopping 238 building projects belonging to the public had stalled. This presents waves of shock to the country's economy because of the increased number of missed opportunities, enlarged costs and also due to revenue losses. It is quite paramount to also understand that the construction projects are funded with borrowed funds as seen in KNBS, (2015) where it is indicated that the credit extended to the sector increased from Kshs. 70.8 billion during 2013 to Kenya shillings 80.4 billion during 2014 and also from Kshs.80.4 billion to Kshs. 106.4 billion in 2015 (KNBS, 2016). However, in KNBS, (2017), this credit to the construction industry went down from Ksh.106.4 billion in 2015 to Kshs. 104.8 billion in 2016 and increased again to Kshs. 109.9 billion in 2017 (KNBS, 2018). This yearly trend of credit increase to the industry is indicative that borrowed funds are extensively utilized in the industry.

1.7 Scope of the Study

This study looks into the macro-economic factors that influence construction output levels in Kenya. These macro-economic factors are inflation rate, population growth rate, exchange rate for Kenya shilling to US dollar, rate of unemployment and weighted interest rate for commercial banks in Kenya. These macro-economic factors are treated as the explanatory variables while construction output in the Country is taken as the endogenous variable. The explanatory variables are the ones found to have a direct impact on the endogenous variable as established by the study.

The study period is forty-three (43) years starting from 1977 to 2019 due to data availability. The data in this study is analyzed using multiple time series regression analysis in the time domain involving multiple regressions (MR) and autoregressive integrated moving average (ARIMA).

1.8 Assumptions

The study assumptions included:

i. That data from KNBS is accurate and adequate
ii. That other variables data was not available over the study period; 43 years
iii. That construction output and macroeconomic variables had a linear relationship.

1.9 Limitations

Time series data of all the six variables were collected. The variables are construction output, inflation rate, population growth rate, exchange rate for Kenya shilling to the US dollar, rate of unemployment and weighted interest rate for commercial banks in Kenya. The data were obtained from the Central Bank of Kenya (CBK) and the Kenya National Bureau of Statistics (KNBS) which covered the longest period possible; from 1977 to 2019 – 43 years. The reason for this being that time-series analysis accuracy is so much dependent on the length of the series. The initial plan of the researcher was to collect the time series data from 1963 but this was not possible due to the challenge of having the data in conformity to the current system of national accounting in Kenya - (SNA) 2008. The research design is a case study with Kenya as an exemplifying case. Generalization of the findings is limited to the case; Kenya.

1.10 Definition of Terms

In this study, the following technical terms, are defined according to Gujarati & Porter (2009), as follows: -

Analysis of time series - It caters for such a fact as to show that data points as taken over a certain period of time, are likely to have key internal structure and should be accounted for. The said structure could include components such as seasonal variation, autocorrelation and difference /trend.

Homoscedasticity - It is a term used in econometrics to imply "Equal variance. The term is used to mean the opposite of heteroscedasticity implying the variance is unequal.

Lag - The lapsed time of an endogenous variable 'Y' in responding to changes in explanatory variable 'X'. The endogenous variable in this case is Kenya's construction output while the exogenous variables remain as the five macro-economic factors.

Stationarity – if a time series has a mean which is constant while maintaining a steady variance during a certain period of time, the series is said to be stationary in econometric terms.

Time series method- It is a succession of observations which are made and organized according to their outcome period.

Unit root - Its presence in a time series makes it non-stationary.

Micro numerosity- This is a term used in econometrics to mean less data.

Multicollinearity – This means high correlations among the independent variables

1.11 Outline of the Study Report

The study report is arranged in five (5) chapters. Chapter number one is the introductory section of the research which delves much on looking at the good and bad side of the effects resulting from macro-economic factors in Kenya on the country's construction industry. The same chapter also stipulates the importance of the anticipated outcome from this research. The following chapter number two, gives a picture of the various and relevant works carried out by different researchers and relating their relevance to this work. Some differences as well as similarities are highlighted for purposes of a deep comprehension of the actual problem. Emanating from the reviewed literature, macro-economic factors that influence construction output levels in Kenya are identified for the research in subsequent chapters. The third chapter puts down the adopted strategy in the analysis of data to enable the achievement of the research aim including its objectives as initially laid down at the commencement of this work. The area covered in the study including the variables of time series are well thought-out at this stage. Chapter number four (4) deals with analysis of data along with its interpretation. Time series analysis of the data is carried out statistically for purposes of establishing existence of the impacts of macro-economic factors on the country's construction industry output levels. The fifth chapter presents suggestion on areas of further research, recommendations and conclusions.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, prior works by other researchers including writers in closely related subject fields are reviewed, compared and knowledge gap finally established. The reviewed literature is carried out on a range of related construction output studies along with the macro- economic factors that affect it. They include the monetary policy factors such as interest rates, inflation rates, and exchange rates. Other included macroeconomic factors are rate of growth of Kenya's population and rate of unemployment in Kenya. Construction demand and the functions of Kenya's Central Bank are also keenly studied. Finally, the knowledge gap is established and the theoretical framework and conceptual frameworks derived.

2.2 Construction Supply and Demand

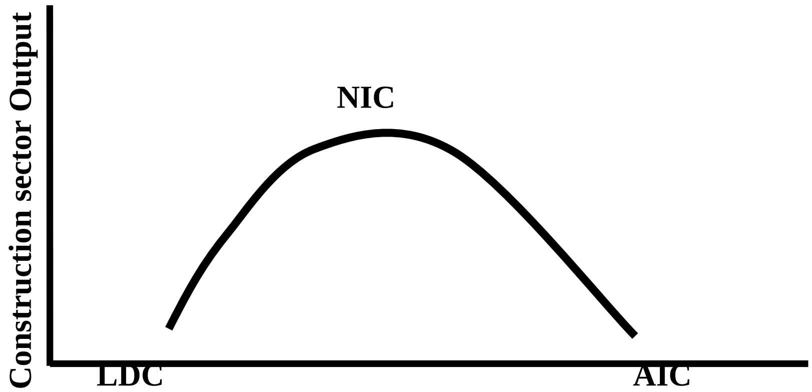
Construction output refers to constructed facilities. It is a common practice to use a technique of quantifying constructed facilities by way of expression into monetary values. This occurs while bearing in mind that the values of money are not subject to investigation (Hillebrandt, 2000). In the country, the task to compile these quantities rest upon KNBS - Kenya National Bureau of Statistics. The KNBS carry out this exercise on the basis of one year to the other.

The principal responsibility of the country's construction industry is to ensure for adequate supply of actual constructed facilities which allow for other human activities to get some space for their operations (Hillebrandt, 2000). It was noted from her that the money expended in constructing every building structure together with all civil/structural engineering works in a given country/economy, within a specified time period; mostly a calendar year, is termed as that country's gross construction output.

Based on her argument, this output is approximated to be in the region of 10% averagely, based on the sum total of world's Gross National Product (GNP).

Even though Mawdesley & Qambar, (2000) described construction industry as part of the major industries posing numerous challenges, it is viewed as among the top class in the whole world from the size perspective. They however felt that, construction industry is still the gateway towards the upcoming and industrialized countries' prosperity in quite varied ways. Therefore, this is in concurrence with other writers and researchers such as Hillebrandt, (2000) that the industry is very important to any economy.

The pattern of construction industry's growth behavior has been studied by a number of scholars. In Hillebrandt, (2000), it is realized that, the pattern in relation to quantity as regards to construction industry output levels and in comparison, with the GDP in any particular economy, goes through evolution following the nation's path of development. This can be observed from changes of a country's development from levels of Less Developed country (LDC), through Newly Industrialized Country (NIC) up to Advanced Industrialized country (ADC). From the foregoing, it can be clearly visualized that, construction activity in a country produces a bell-shaped outline which indicates the lowest points occurring close to the start of LCD and the final part of AIC. The highest point happens at NIC. In an attempt to explain this phenomenon, Hillebrandt, (2000) clearly pointed out that this is observable in the reduction of investment assets as the country climbs the ladder of higher economic growth. The said changes are long term and do take place and ordinarily occur taking the path of an economy's cycles of Kondratiev and Kuznet types. The periods are 15 – 25 years and 45 – 60 years for Kuznet and Kondratiev respectively. Accordingly, the ideal situation for a third world country like Kenya is having construction activity and growth which are continuous. See fig. 2.1.



A Country's GDP (**Source:** (Bon, 1992)

Figure 2.1: Bon's curve

While attempting to approve of the existence of the said relationship which was originally the idea of Bon, (1992) and reiterated that it is highly empirical, Girardi & Mura, (2013) saw that the supporting writing which accompanied the model is only a mere description. In this regard, the duo took it up as a research gap. They proceeded to give a stronger proof in support of Bon's proposition by means of 2000 - 2011 period panel data collected from world countries (Girardi & Mura, 2013). They established that this relationship only worked if logarithmic transformation was performed on the data. This carried an implication that this curve was actually asymmetric with regard to its maximum. The meaning is that, a construction industry's activity relative magnitude seemingly tried going up in third world countries, reaching the peak of activities during industrialization period and begin dropping at a sluggish pace in the first world countries which seem to be fully industrialized, approaching the state of stabilization in developed economies.

2.2.1 Global Perspective of Construction Industry

Construction industries in any part of the world perform similar activities. Hillebrandt, (2000) for instance says it is a sector which involves itself with the activities including construction of civil engineering structures, erection of buildings, repair and demolition of the same structures in any specific economy. Even though, it is not all that easy, to define the industry in such a more irrefutable manner a good number of researchers/writers have come up with somehow different definitions of the industry. Good examples of such writers and researchers are identified. They include Bon, (1992), (Harvey, 1996) and (Lavender, 1992). However, a profound definition relating to accounts of national income commonly used in a number of advanced and more industrialized countries states that, construction industry includes the works which are commonly done on construction sites and involves assembly of building materials; these materials consist of components which are availed by different manufacturers within the economy's sector of manufacturing; deliveries to the sites comprises those in business sector including transportation; assembly is performed in line with necessary procedures which are well stipulated, along with management plans drawn from the sector of services via commerce industry; funds are supplied by financial industry via the financial services sector; construction industry is the supplier of all construction output followed by their delivery to real estate industry which serves under the services sector as observed in Bon, (1992), Harvey, (1996), Lavender, (1992) and Myers, (2008).

With a view of the construction activities definition stated above, two industries can be said to be intertwined. These are construction industry and the real estate industry. The construction industry comes up with facilities which are constructed through construction and production process whereby, the real estate works with output of constructed facilities. Demand for constructed facilities can be satisfied through lease/purchase of houses from existing accumulated number of houses from real estate markets. The demand can also be met through purchase of newly build/ or rehabilitated building structures within specific country's construction industry (Akintoye & Skitmore, 1991), (Briscoe, 1992), (Hillebrandt, 2000), and (Raftery, 1992). The industry's responsibility is nonetheless to make available services to the section of every constructed open space demand contained in the country which is not yet met by the existing stock of building space available. Due to this reason, one should note that a discussion relating to the industry's issues is more liable to overspill to various other matters which may squarely be related with real estate sector as noted in Hillebrandt, (2000) and Raftery, (1992).

2.2.2 Construction Industry of Kenya

Kenya is a nation within East Africa. This country is currently holding 48.3 million in terms of population which translates to a density of population of 82.5 people in a square kilometer as at the month of May in the year, 2017. The GDP of the country (Gross Domestic Product) or in other words (GDP – the parity of purchasing power) of the country is 63.4 billion US Dollars and a GDP rate of growth expected to stand at 5.7% within the year (Countrymeters, 2017) and (Trading Economics, 2017).

By tradition, the Kenya's economy has been majorly agricultural. The agriculture produces contributing well over 50% towards the GDP including employment of over 80% of those people who can be said to be actually, working in various sectors of the country's economy (Mbaya, 1984). Food and Agriculture Organization of the United Nations (FAO) breaks down the agriculture contribution to the GDP into two parts. Firstly, is the direct contribution to the GDP of about 26% of the total GDP of the country. The second part is the indirect contribution to the economy which accounts for about 27% of the GDP (FAO, 2020). The current position is that, even though the agriculture gives employment to such a big percentage - (80%) of the Kenya's labor force, the GDP share remains to be about 32.7%, and is well above the construction industry's share which is a mere 18% and much below services industry which currently stands at 49.3%. (CIA, 2017). Support of infrastructure, within the country's economy is the responsibility of construction industry through its activity of erecting buildings, housing supply, spaces like for offices, retailing of space, factories' construction, roads/railways including schemes of irrigation and water supply.

Gross Fixed Capital Formation (GFCF), is a statistical measure of the value of all the acquisitions of fixed assets, whether fresh or existing. This (GFCF), records about 40% from construction industry and translates to 4% of the country's GDP. It is also estimated that about 80,000 people are employed by the construction industry (Mitullah & Wachira, 2003). Though, during the 2000s, its input in percentage towards the GFCF was constantly rising from the year 2000, it dipped in 2001 and picked up again from 2002 to 2004 (K'Akumu, 2007). This is an indicator that there were well sustained activities of construction in the country during that period. As shown below in table 2.1 which paints a clear picture of this scenario.

Table 2.1: Percentage contribution to GFCF of Construction Industry in Kenya

Year	Contribution to GFCF (%)
2000	47.9%
2001	46.4%
2002	47.8%
2003	53%
2004	51.6%

Source: (K'Akumu, 2007)

The Kenya's Construction industry in most cases is observed to maintain an upward growth trend. In recent times, say for example in 2013 and 2014, a report on economic survey shared by KNBS (Kenya National Bureau of Statistics) bore an indication that Kenya's construction sector contributed 4.8% towards the GDP (Gross Domestic Product). This GDP went up from Kshs.4.73 in 2013 to Kshs.5.36 trillion in 2014 and this upward change translated to a nominal rise of 13.3% (Macharia, 2015). The indication here is that the industry is growing, though very slowly with lots of fluctuations.

2.2.3 Construction Demand in Kenya

Lack of constructed facilities' demand is a clear sign of a probably retarding construction industry. Based on Gruneberg, (1997), what determines the activity in the building industry is the interaction of property costs, rates of interest and building price. He further notes that even long ago; way back in the 19th century, this kind of interaction was well respected since building prices and property costs are influenced by lending interest rates. This is actually when, based on Gruneberg, (1997), “The Economist's Commercial History and Review” during that particular time referred as the phase of diminishing interest rate alongside soaring demand for property, which simply served as a huge encouragement to many developers who really expanded their supply to exceed market sustainability. The main reason for many developers to develop properties in numbers beyond what could actually be sold in the property market is another question of going to understand the “theory of supply and demand” including its function in the constructed facilities market. Most essential to note is that various factors do affect the demand side, while other very distinctive and alike groups of conditions are found in the supply group of determinants. For reasons of comprehending all the market forces in action, a move which is quite systematic is applied, whereby a single variable is examined in turn. In Hillebrandt, (2000), it is indicated that the cost as charged by developers for their construction products, may it be for rent or may it be for sale, various factors come in to play and display their influences. In addition to construction costs, they include price for land, system of taxation and price for capital. This study examines the effects of macro-economic factors on construction output levels in Kenya which include interest rate, inflation rate, Kenya shilling to US Dollar exchange rate, population growth rate and unemployment rate which are not significantly different from those highlighted in Hillebrandt, (2000).

Kenya, being a fast-developing country, its construction industry is going through rapid expansion due to the huge investment the country has pumped into the industry. The reason for this heavy investment by the government, is the need for improvement of some of the sectors of construction industry in the country. The sectors include mainly housing and infrastructure; roads, railways and sewers (Hamza, 2020). He further alludes that, the demand for constructed facilities such as commercial, residential, industrial and prefabricated low-cost housing has been propelled by rapidly increasing population. It is therefore evident that, this demand for constructed facilities is not likely to tone down in the near future and hence the need for the country to come up with sound policies to put the construction industry in a stable position to meet this demand.

For this to happen, it is first important to establish if macro-economic factors can be used to guide policy formulation in the country.

2.3 Macro-Economic Factors Influencing Construction Demand

One of the major problems facing most of the countries in the world is the provision of suitable housing. A major contributor to this is the bulging population among many others (Kadir, Lee, Jaafar, & Sapua, 2005). It is therefore evident that these two macro-economic factors are intertwined in that, demand for housing is directly proportional to population growth rate and hence, it is very imperative for policy makers to be aware of this fundamental factor that causes elevated demand for housing for purposes of formulating policies which can address it fully.

In Kenya, housing is currently a biting social issue even though the government is trying to stamp it out through various initiatives. An example is the 'Big Four' agenda initiated by the current president where one of the items is creation of 500,000 new homes in the next five (5) years from 2017 to 2022 (KEPSA, 2017). According to KEPSA, (2017), the big four agenda by the current president of Kenya include enhancement of manufacturing sector, provision of affordable housing, provision of universal health care coverage and enhancement of food and nutrition security. In the agenda of enhancement of the manufacturing sector, construction industry is key since in its absenceprovision of housing cannot be realized.

According to KEPSA, (2017), the government is seeking to address the agenda for affordable housing provision through:

- Reduction of mortgage cost to enable citizens to own homes without paying more than what they are currently paying as rent.
- Minimizing construction cost by encouraging use of innovative technologies and materials.

- By mobilizing low-cost financing for investment in large scale housing construction from public and private sector.

From the foregoing, as highlighted by KEPSA, (2017), it can be clearly seen that thorough understanding of macro-economic factors that impact on construction output levels in Kenya is paramount.

Demand for other constructed facilities produced by other sectors of construction industry is also high in Kenya. This includes for example, demand for commercial buildings such as hotels, offices, factories, warehouses, garages, shops and many others. Most of these products of industrial and commercial sectors of construction industry are usually not demanded for their own sake, but for the purposes of the activities that are carried out in them (Myers, 2008). Due to this reason, he says this is derived demand because buildings are neither rented nor purchased to provide satisfaction, but due to their ability to provide spaces for production of goods that can be sold in the market for profit. Therefore, in Kenya, the shortfall in nearly all types of constructed facilities has never been adequately addressed and hence the need to establish some of the factors that could be contributing to this problem.

In pursuit of this understanding, there are some very important markets one needs to look at for purposes of understanding their operations and their link to construction industry. The three important markets according to Cooper & John, (2012) are:

i) Credit market – this market is characterized by interest rates which are key components of this market. This becomes evident where owners of physical and monetary capital are rewarded either directly or indirectly by receiving or earning a kind of interest payment as a result of their credit arrangement (Myers, 2008). Interest rate is the cost of capital to the borrower.
ii) Labor market – where unemployment is a major issue of the market. Even though Hillebrandt, (2000) says that there is lack of management expertise

world-wide, in the construction industry projects, unemployment is currently a biting problem in many countries of the world.

iii) Foreign exchange market – in every new construction project coming up, one has to make a choice of materials to be used in the project, labour requirement and probably the construction plant and equipment to be used in the project (Myers, 2008). The reason behind this being that, most of the equipment and some of the materials have to be imported.

These markets are very essential to construction industry in diverse ways as exemplified below (Cooper & John, 2012). Additionally, GDP growth rate is quite essential in the management of macroeconomic matters. In the past according to Myers, (2008), economies have suffered the great depression followed by stagflation (stagnation and inflation combined), and currently they are facing credit crunch. This is causing fears that economies are likely to plunge into recession and therefore are trying their best to maintain economic stability.

2.3.1 Influence of Credit Market (Interest Rates) on Construction

A credit market is also known as loan market. It is a market in which the credit is extended by lending institutions to borrowers. These credit arrangements, also called loans, are specific kinds of contracts. A simple credit as explained in Cooper & John, (2012) is a contract which specifies three components:

1) The amount being borrowed,
2) The repayment date, and
3) The amount being repaid.

Credit contracts are legally created documents, and therefore, many other details will be written in the contract in addition.

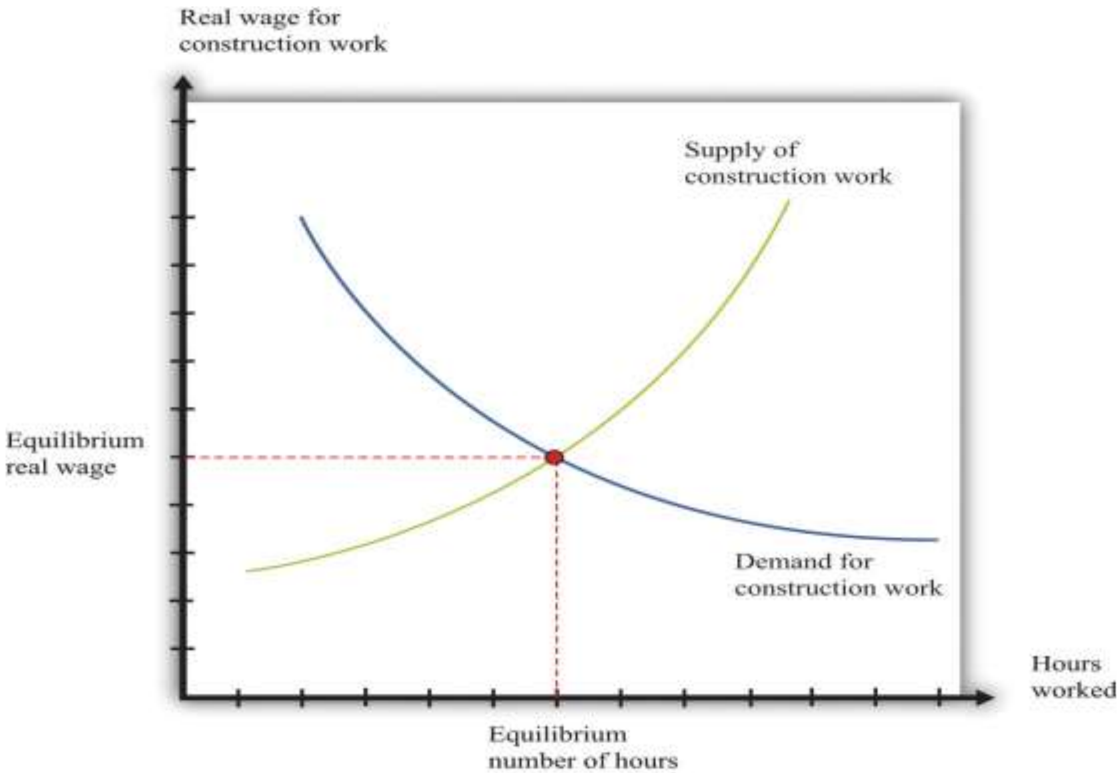
It is also important to note that credit facilities are very key to construction industry since construction projects are mostly funded by way of borrowed funds as seen in

KNBS, (2015) where it is indicated that the credit extended to the sector increased from Kshs. 70.8 billion in 2013 to Kshs.80.4 billion in 2014 and also from Kshs.80.4 billion to Kshs. 106.4 billion in 2015 (KNBS, 2016). However, in KNBS, (2017), this credit to the construction industry slowed down from Ksh.106.4 billion in 2015 to Kshs. 104.8 billion in 2016 even though it rose to Kshs.109.9 billion in 2017 (KNBS, 2018). This is a clear demonstration that the relationship between the credit market and construction industry is indispensable. The future repayment according to Cooper & John, (2012) can be summarized in a single current price and number, referred to as the nominal interest rate.

In Cooper & John, (2012), there are two of the most significant players in the credit market. These are the government and the monetary authority, which is the CBK in this case. It is an important point to note that, according to Cooper & John, (2012), credit market is the one which brings together the credit suppliers (households) and credit demanders; other households, firms, and the government. Market equilibrium is attained by adjusting interest rates.

2.3.2 Influence of the Labour Market on Construction Industry

Labor market is a place where labor services are traded. Supply of labour is from households whereas firms demand labour. Market equilibrium is attained by real wage adjustment. Firms demand labor in the labour market, and households supply it (Cooper & John, 2012). In fig. 2.2 below, supply and demand curves for construction workers are illustrated. The hourly real wage is the price of labor which is paid to construction industry workers.



Source: (Cooper & John, 2012)

Figure 2.2: Equilibrium in the Market for Construction Worker

Individual labour demand by a firm originates from the fact that workers' time is an important input in the process of production. This demand curve obeys the basic law of demand that: as the real wage goes up, the quantity of labor demanded goes down. Therefore, when real wage is higher a firm's demand for labour services will be less resulting to employment of fewer workers and/or reduction of the hours of workers in response to the higher labour cost by production reduction (Cooper & John, 2012).

It is seen in fig.2.2 that the labour supply is upward sloping. If the real wage goes up, households supply more labor due to the following reasons:

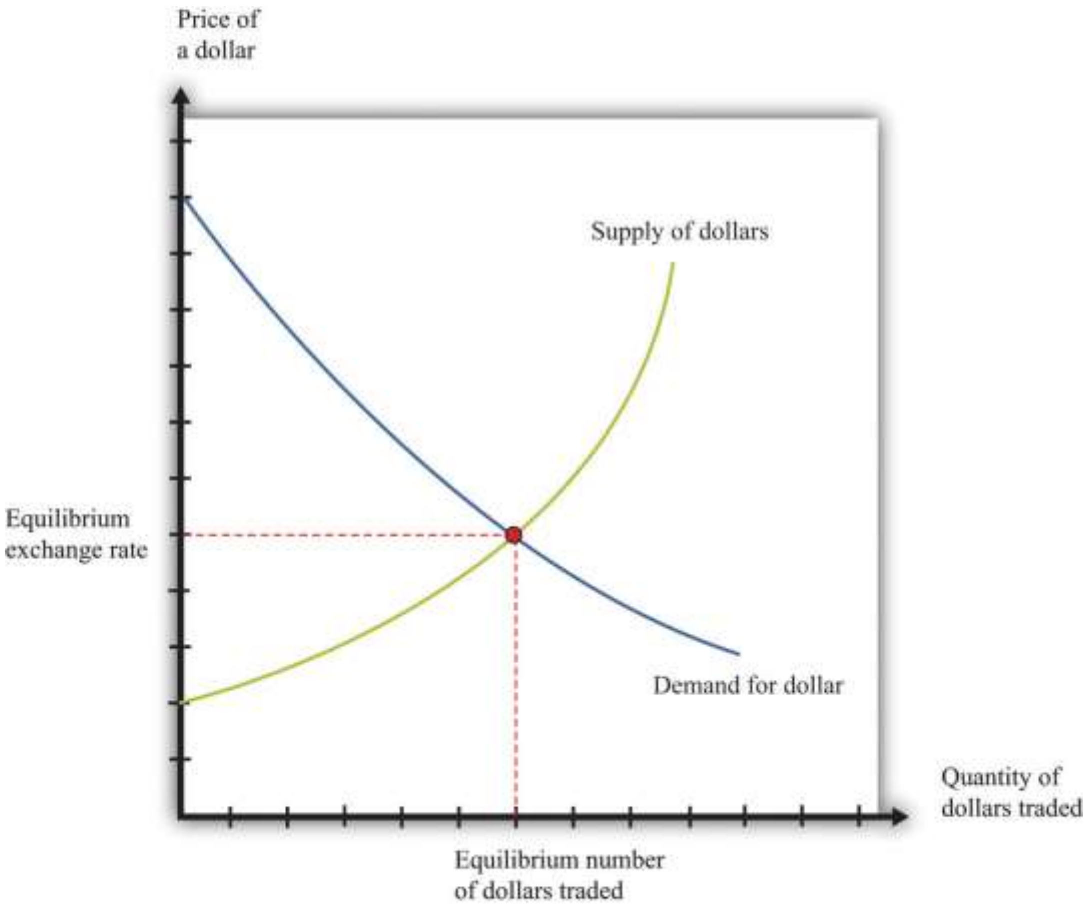
1.) Higher wages encourage people to work for longer hours
2.) Higher wages encourage many people to enter into the labor force and search for a job.

It is therefore necessary to note that real wage is adjusted for inflation through the following formula: $real\ wage\ =\ \frac{\text{nominal wage}}{\text{Price levels}}$ (**source:** (Cooper & John, 2012)

It is interesting enough to realize that construction industry, while providing a solution to the housing problem, at the same time, it is also giving employment to the unemployed in a country. In 2015 for example in Kenya, the construction sector employed 148,000 people up from 132,900 people it employed in 2014 (KNBS, 2016). This employment volume into the industry continued to swell from the 148,000 in 2015 to 163,000 in 2016 as observed in (KNBS, 2017). Further, it is also observed in KNBS, (2018) that the industry employed 167,900 people in 2017.

2.3.3 Influence of Exchange Rate Market on Construction Industry

A foreign exchange market is a market where all currencies are traded. The price in this market is the actual price of one currency in terms of another currency and it is usually referred to as the nominal exchange rate (Cooper & John, 2012). On the other hand, Samuelson & Nordhaus, (2010) defines the foreign exchange market in almost similar way. They say that the foreign exchange market is the market in which foreign exchange rates are determined and currencies of different countries traded. It is further seen in Cooper & John, (2012) that foreign currencies are usually supplied by foreign family units, firms, and governments that desire to buy goods, services, or financial assets such as stocks and bonds which are in form of domestic currency. Take an example, of a Canadian bank wanting to purchase a bond from US government. It has to sell the Canadian dollars in order to purchase the US dollars. The basic law of demand and supply applies: as the cost of one dollar goes up, the demanded quantity of that currency declines. The market (foreign exchange market) brings together the demand side and the supply side of the foreign currency. The foreign exchange rate, which is the price of one currency in terms of another, is the adjusting factor to attain equilibrium of the market. See fig.2.3 below.



(**Source:** (Cooper & John, 2012)

Figure 2.3: Equilibrium of Foreign Exchange Market

As observed in Samuelson & Nordhaus, (2010), an open economy engages in trade internationally. Due to this fact, Kenya can be said to be an open economy. Therefore, construction materials that are imported form part of the imports and this makes the foreign exchange market very vital to the construction industry. The current account balance was 6.7% of the Kenya's GDP in 2017 (KNBS, 2018).

2.3.4 Gross Domestic Product (GDP)

This is the most important concept in macro-economics. It is a measure of the total aggregate goods and services that a country produces in a single year (Samuelson &

Nordhaus, 2010). GDP is actually a part of the product accounts and national income, which are a mass of statistical tools enabling policymakers in determination of whether there is economic contraction or expansion and whether there is a looming danger of inflation or economic recession. GDP per capita is used by economists to determine the development level of a country as it is highlighted in Samuelson & Nordhaus, (2010). Therefore, Gross Domestic Product (GDP) is defined in Samuelson & Nordhaus, (2010) as the name given to the aggregate market worth of all final services and goods produced within a year's duration in a country. It is the most comprehensive measure of a country's aggregate output of services and goods**.** Averagely, 5% of the GDP in Kenya is contributed by the construction industry and for this reason, this variable is dropped from the list of variables analyzed in this study.

In symbols, GDP is determined as follows:

$$GDP = C + I + G + X \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.1)$$

Where: C = consumption

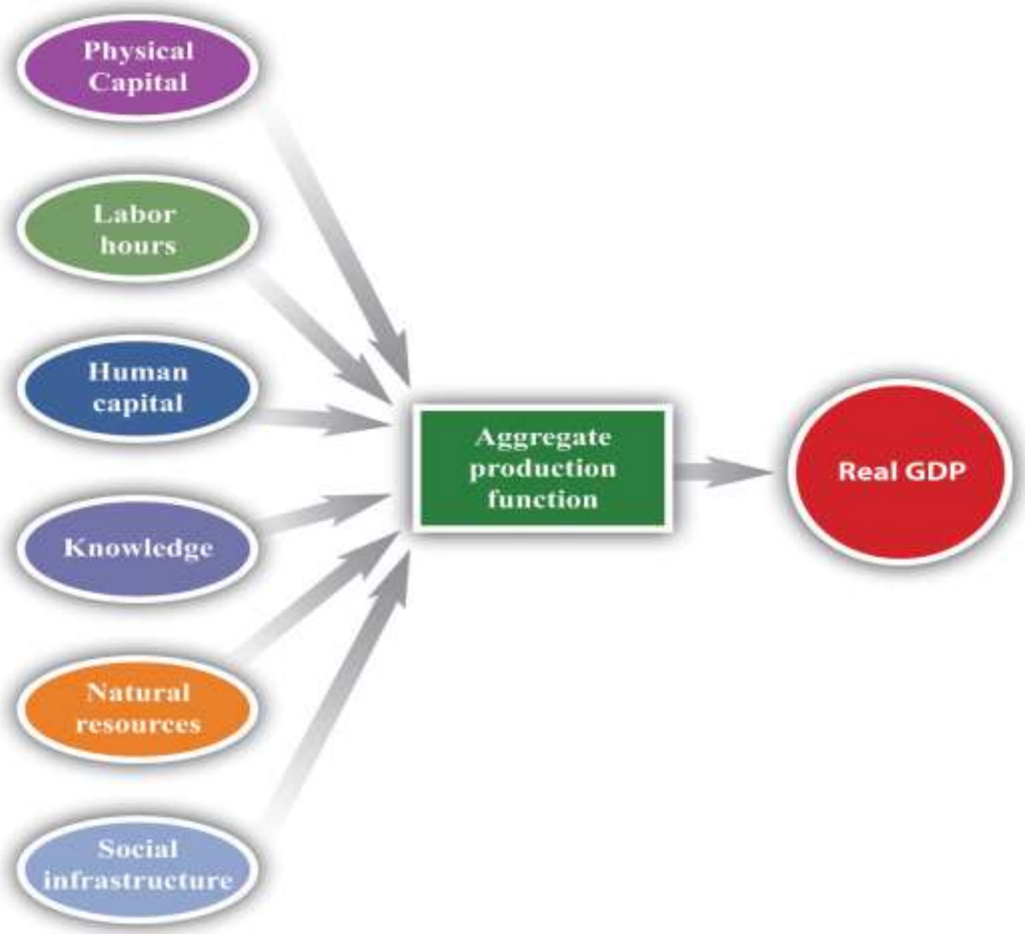
I = gross investment

G = government purchases of goods and services

X = net export (Samuelson & Nordhaus, 2010)

Given that GDP is used for various purposes, key to all these purposes is the measure of overall economic performance of a country (Samuelson & Nordhaus, 2010).

In a given economy, production capabilities can be summarized with an aggregate production function. In other words, this is the real GDP. It is a combination of the given economy's physical capital stock, labour, natural resources, knowledge, social infrastructure and human capital that produces output – real GDP (Cooper & John, 2012). The real GDP is further explained diagrammatically as hereunder in figure2.4.



Source: (Cooper & John, 2012)

Figure 2.4: The Aggregate Production Function

Kenya's GDP growth over the last few years has been fluctuating a lot. It grew by 3.3% in 2009, 8.4% in 2010, 6.1% in 2011, 4.5% in 2012, 5.9% in 2013, 5.4% in 2014, 5.7% in 2015, 5.8% in 2016 and 4.9% in 2017 (KNBS, 2018), (KNBS, 2017), (KNBS, 2016) and (KNBS, 2015).

2.3.5 GDP Growth Rate

The growth rate of the GDP is a major concern for all governments. According to Myers, (2008) a sustained economic growth (GDP growth) is one of the governments' macroeconomic objectives that include price stability, full employment, positive trade balance and environmental protection. This is a major indication on how GDP growth rate is important to any economy. Simon Kuznets – an economist, developed an idea of tracking what a whole economy produces (OpenStax College, 2014). It is therefore the gross domestic product (GDP) that tells the size of a country's economy.

Steady sustainable economic growth is a major dream of all nations of the world. It is usually a long-term goal of most of these governments to achieve stable increases in their capacity of production. Therefore, at this juncture, it is important to realize that annual change in output (GDP growth rate) is what government use to measure growth of the economy (Myers, 2008). It is therefore the annual percentage positive change in GDP which is referred as the GDP growth rate.

This variable is excluded from the list of variables in this study since construction output forms part of the GDP of the country.

2.3.6 Population Growth Rate

Kenya's population according to KNBS and Economics, (2016) is 44 million. This population represents 0.60 percent of the current world´s total population and it can be argued that every one person in every 168 people on the planet is said to be a resident of Kenya (Economics, 2016). As at 7th May, 2019, the population stood at 52 million representing 0.68% of the world population. The huge number in population requires shelter as one of the basic needs as seen in Maslow's hierarchy of needs. While fulfilling this need, the researcher intends to find out whether it also impacts on the construction output as well.

2.3.7 Inflation Rate

This is the rate at which generally commodity prices go up within an economy as mostly indicated by the CPI (Consumer Price Index). The inflation is usually taken as the change in percentage of the Consumer Price Index in a country over a single year period. There are different types of inflation depending on its rate. For example, we may have hyperinflation where the inflation rises very rapidly to very high levels and stagflation where the economy stagnates coupled with inflation (Fernando & Boyle, 2021).

The impact it has on construction output is that, when the prices of major commodities go up, like for instance cement prices, the construction industry delivery may drop due to high-cost factor. As well, whenever essential commodities prices go up, people mostly tend to embark on meeting essential needs and hence stop the thought of investing in industries such as construction because of the huge investment outlay involved because of probably the heightened inflation rate.

This could be viewed as an important reason why rate of inflation is a major monetary policy focus of the MPC (Monetary Policy Committee) of the Kenya's central bank to maintain it as low as practicable and keep stabilized prices in the economy.

The Government via the Central Bank of Kenya fixed the overall medium-term maximum target of inflation at 5%. This was set for 2015/2016 Fiscal Year to allow for a margin of plus or minus 2.5 percent. This is somehow achievable since the rate has been hovering around 7% in 2017.

2.4 Construction Demand Prediction Models

A number of models have been developed for economic forecasting. Some of these models have been widely applied in demand forecasting than others (Gujarati & Porter, 2009). The table below displays the main models that have been mostly preferred by various researchers and have been in use over the last number of years.

Table 2.4: Construction Demand Prediction Models

Item	Model	Description
1.	Exponential Smoothing Methods	Usually applied to fit historical data of a specific time series. Various methods exist such as: 1. Holt – Winters' method 2. Holt's linear method and 3. Single exponential smoothing
2.	Single Equation Regression models	This is mainly used based on economic theory. It postulates that demand is a function of a number of factors such as prices, income, interest rates and many other economic factors. This model has a limitation that errors occur if the forecasting duration is too long.
3.	Simultaneous equation regression models	They were widely used in the 1960s and 70s before what came to be known as the Lucas critique. Lucas attributed the limitation of the models to changes of economic policies of a country. Economic theories are usually the basis of simultaneous equation models.
4.	ARIMA Models	It is popularly referred to as the Box – Jenkin methodology and technically known as ARIMA methodology. Its main focus is not on construction of single or simultaneous equation but on the analysis of probabilistic and stochastic properties of an economic time series based on its own lagged values. These properties are not based on or derived from any economic theory and therefore, they are sometimes referred to as atheoretic models.
5.	VAR Model	In this methodology, several endogenous variables are considered together and for this reason, the methodology has a superficial resemblance of simultaneous equation model. There are usually no exogenous variables in this model since every endogenous variable is explained by its own lagged values or lagged values of other endogenous variables.

Source: (Gujarati & Porter, 2009)

Due to the nature of data collected for analysis in this research and the objectives, single equation regression models, VAR model and ARIMA models are selected and applied in data analysis.

2.4.1 Demand Forecasting

Demand forecasting is quite essential for any organization involved in the manufacture and supply of goods. This is because it acts as an enabling tool for any firm to carry out its planning and scheduling activities accurately (Ghanbari, 2019). This is therefore an indication that if the forecasts are accurately done, the firm can accurately put together the resources required to meet the demand.

Demand forecasting has been carried out for a variety of reasons. Ghanbari, (2019) outlines some of these reasons while citing various writers and researches. They include reduction of inventory costs in addition to heightened satisfaction of any business customers as seen in Carbonneau et al., (2008). While carrying an investigation on the applicability in demand forecasting of three advanced machine learning methods; support vector machines, recurrent neural networks and neural networks, conclusion was reached that support vector machine and recurrent neural networks performed better in terms of accuracy even though it was not statistically significant than regression model (Carbonneau, Laframboise, & Vahidov, 2008). It is therefore imperative for any organization to carry out demand forecasting for purposes of accurately meeting the demand of its products. This has not been the case for Kenya since the Kenya's construction industry has been failing to meet the country's demand for constructed facilities since independence.

Research on construction demand forecasting is an ongoing activity in different countries in the world. This is elaborated hereafter as the researcher focuses on previous studies by different researchers in the world. It is an indication of the importance attached to this subject.

2.4.2 Researches on Construction demand Forecasting

Numerous researches have been done on construction demand forecasting in various countries around the world. In Kenya, there is only Kivaa, (2008) who studied the industry from 1964 to 2003. In his study, he noticed that Kenya's construction industry output is influenced by its own earlier performance and the country's GNP and the index of misery. It was also noticed in this study that the industry's output growth fluctuated a lot. He however saw in his study that the model developed, could not be applied to predict demand for constructed facilities in the country up to an appreciable degree of accuracy. In his study, an R^2 value of 0.37 was obtained compared to 0.48 obtained in this research. He therefore recommended further research on this subject.

Another very recent study on demand forecasting is by Ghanbari, (2019). His intention was to come with the best forecasting method from the various ones available. This was done by looking into Construction Demand Forecasting Based on Conventional and Supervised Machine Learning Methods. He noticed that machine learning techniques were able to produce more accurate results than any other method for his intended purpose.

Two other researchers jointly studied the construction industry of Singapore. Their aim was to forecast construction industry demand, price and productivity in Singapore applying the Box-Jenkins approach (Hua & Pin, 2000). The duo claim that in most academic researches, the traditional Box–Jenkins approach is commonly applied as a yardstick technique for univariate analysis methods due to its well-structured modeling basis and reliable performance in forecasting. They therefore derived three (3) models for the three variables; construction demand, construction tender price and construction productivity in Singapore. The models were evaluated for their predictive accuracy using forecasts of an out-of-sample. Therefore, Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) were adopted for the purpose. In the case of RMSE, it was realized that the prediction was consistently below the standard error for all the three models which was a clear indication of good prediction accuracy. MAPE prediction fell within the widely appreciable limit of below 10% for the three (3) models derived in the study. Productivity had the highest MAPE and therefore it was the lowest in accuracy and tender price was the second less accurate. The lowest in MAPE was demand forecasting and this meant that it was the highest in terms of accuracy among the three models.

It is now obvious that there is a keen interest by a single scholar who is persistently studying the construction industry of Singapore. This is none other than Bee Hua, (1996) who studied construction industry of Singapore using twelve (12) economic indicators of the industry. The economic indicators are per capita GDP, GFCF (construction and works), real GDP, building materials price index, money supply (savings and others), CPF withdrawals (home ownership), prime lending rate, consumer price index, property price index (residential), labour force and unemployment rate. His main focus was demand prediction for Singapore's residential construction sector in the country's construction industry. He applied two techniques which are namely Artificial Neural Network (ANN) and Multiple Regression (MR) analysis to carry out a comparative study for purposes of establishing the best technique to produce more accurate predictions than the other. Therefore, two models were developed; ANN and MR model using the same set of data and their forecasting accuracy evaluated by their relative measure of mean absolute percentage error (MAPE). It was noticed that MAPE for both models were below the generally accepted 10% but MAPE for ANN was less than that of MR. This meant that ANN produced more accurate prediction results than MR.

Still on construction demand forecasting, it is realized that a number of people have developed some reliable forecasting models while studying construction industry of different countries. This can be observed in a study where modelling of private new housing starts in Australia was done (Flaherty & Lombardo, 2000). In this study they applied causal and non-causal techniques to establish the relationship existing between Australia's economy and housing starts in the country. Their conclusion was that, if proper model identification and estimation is done, the same can be used to carry out forecasting of construction demand in the future. Different methods of construction demand forecasting which have been applied in the study of different construction industries of the world in the past are outlined hereafter. Some of the methods have been used for demand forecasting for various other goods and commodities other than constructed facilities (Ghanbari, 2019).

2.4.3 Construction Demand Forecasting Methods

Time series forecasting refers to the use of a statistical model to carry out prediction of the future values based on the previous values observed. In the recent past, researchers have applied different methods in construction demand forecasting. One of the widely used methods is the Box-Jenkin method which is commonly referred to as autoregressive integrated moving average (ARIMA) (Hua & Pin, 2000) and (Hua, 1996). This is a very popular method with researchers even though other methods have proved to be more accurate in forecasting (Ghanbari, 2019) and (Hua, 1996). The following table 2.5 gives a glimpse of the various methods which are applicable in demand forecasting.

Table 2.5: Construction Demand Forecasting Methods

Item	Method	Method Application Examples/Authors	Author's Main Focus	Critique &/or Knowledge Gap
1.	ARIMA (Autoregressive integrated moving average)	(Hua & Pin, 2000)	Residential Construction demand forecasting	Relevant and insightful
2.	ANN (Artificial neural network)	(Hua, 1996)	Residential Construction Demand Forecasting Using Economic Indicators: a comparative study of artificial neural networks and multiple regression,	It is very costly and was not relevant to this study
3.	MR (Multiple regression)	(Hua, 1996)	Residential Construction Demand Forecasting Using Economic Indicators: a comparative study of artificial neural networks and multiple regression,	This was quite relevant to this study and was very insightful
4.	Random Forest (RF)	(Momade, Shahid, Hainin, Nashwan, & Umar, 2020)	Modelling labour productivity: a comparative study on classifiers performance	Irrelevant to the study
5.	Single exponential smoothing	(Flaherty & Lombardo, 2000)	Modelling Private New Housing Starts In Australia	Irrelevant to the study

Table 2.5: Construction Demand Forecasting Methods (Cont'd)

Item	Method	Method Application Examples/authors	Author's Main Focus	Critique &/or Knowledge Gap
6.	Brown's double exponential smoothing	(Flaherty & Lombardo, 2000)	Modelling Private New Housing Starts In Australia	Irrelevant to the study
7.	Holt's exponential smoothing	(Flaherty & Lombardo, 2000)	Modelling Private New Housing Starts In Australia	Irrelevant to the study
8.	Winter's exponential smoothing	(Flaherty & Lombardo, 2000)	Modelling Private New Housing Starts In Australia	Irrelevant to the study
9.	Classical decomposition of time series	(Flaherty & Lombardo, 2000)	Modelling Private New Housing Starts In Australia	Irrelevant to the study
10.	Trigonometric seasonal forecasting	(Flaherty & Lombardo, 2000)	Modelling Private New Housing Starts In Australia	Irrelevant to the study
11.	Support vector machine	(Momade, Shahid, Hainin, Nashwan, & Umar, 2020)	Modelling labour productivity: a comparative study on classifiers performance	Irrelevant to the study

2.5 Theories Related to Construction Output

How theory and empirical research relate has been a subject of controversy. This is due to certain social scientists assuming that we initially need to carry out an intense empirical work for purposes of preparing the base for a good social scientific theory. In the same way, others have asserted that an empirical research in the absence of prior all-inclusive theoretical evidence would at most yield worthless and the most horrible is that the results shall be erroneous. Theory is as essential as it is inescapable. In the absence of it, learning would be impossible or even acting in a consistent approach; with no generalizations and good abstractions, this world would be in existence for everyone only as a disordered patchwork of distinct, disengaged experiences and sensory impressions (Joas & Knobl, 2017). Therefore, the need for theory in academic work cannot be overemphasized.

2.5.1 Theory of Demand

Demand is a relationship presenting the quantities of a particular good that consumers of the commodity are agreeable and have the ability to pay money for at different prices in a given period, all other things being held constant (Mishra, 2016). It is therefore imperative to note that, presence of demand for a particular commodity in any market is indicated by prices of the good, the tastes or preferences of the consumers, the number of consumers being considered, the income of the consumers, prices of related goods, available number of goods and the expectations of the consumers in regard to the product's future prices (Eckert & Leftwich, 1988). Demand for a specific commodity implies there is desire to obtain it, willingness and ability to give payment for it. It is an economic law that shows the relationship between commodity price and the quantity demanded for the commodity. The quantity of a commodity demanded in a given duration of time relates inversely to the commodity's price, if all other things are held constant. A demand schedule can be said to be a table that display the relationship existing between a price of a commodity and the demanded quantity of that commodity as explained by Mishra, (2016). Since construction is a business like any other, the price levels of its commodities (construction output) are subject to this theory.

2.5.2 Theory of Supply

Supply denotes the quantity of a good that producers are willing and at the same time are able to offer onto a given market at a given price in specific time duration. The law of supply states that, as the prices of commodities go up, so as the businesses increase supply to the market. A supply curve indicates the relationship existing between prices and the number of commodities a firm is willing to bring to the market and be able to sell. A good example is the prices of construction output and the number the developers can avail in the real estate/ constructed facilities market (Tutor2u, 2015). Supply of construction industry products in terms of shelter in Kenya has never been anywhere near the demand for it. The major reason for this has been related to demographics, high cost of construction, inadequate availability of finances and high cost of the finances. Inadequacy in supply of housing units in particular in the world has also been associated with rapid urbanization and megatrends (Arvanitis, 2013) (Bickerton & Grunerberg, 2013) (Government of Kenya, 2004). Therefore, the supply side of the constructed facilities needs to do something in regard to its capacity to supply the goods and meet the ever-increasing demand for the commodity.

2.5.3 Theory of Value

Theory of value has been an issue of interest to many philosophers and economists. It has also been a subject of an ongoing discussion about how well to define it and it can be viewed as quite important as regards construction output, not only in Kenya but also anywhere else in the world. One of those philosophers and economists who has tried to define and explain this theory is (Taylor, 1996) who said that *value is identified as the element which organized the economic life of society, as the basis for deciding what to produce, how to produce it and who gets it.* According to Taylor, 1996 it has been seen that the rummage around the theory of value is in actuality a search for a consistency and foundation for economic theory since a theory of value is any economic theory that tries to provide an explanation about value of exchange and prices of commodities and services. This has therefore led to the realization that theory of value can be viewed in several dimensions which include labour theory of value, the marginal theory of value and a single theory of relative price (Taylor, 1996). This is dependent on the intention of coming up with the establishment and people's expectations. Therefore, according to Taylor, 1996, the ideal theory of value is usually subjected to an evaluation based on the following background reasons that:

- Value should give some sort of relationship between ***relative prices***, or establish some relative prices given the lack of routine disturbances. The deep-seated idea is to scrutinize the underlying forces to relative prices in a sense of causation; it is usually not very necessary for them to be given a quantitative analysis.
- The factors that determine income distribution should be identified by the theory of value. If magnitude of profit cannot be identified, the theory of value should pinpoint the external forces to the system of economy which help in determining the profit magnitude.
- The forces that lead to growth of the economy should be identifiable in the theory of value.

From the foregoing, the importance of theory of value to the construction industry and the economy in general is clearly visible.

The real estate sector also has its own share of benefits from the theory of value. From this perspective, it is clear that the real estate market and the valuer share similar problems (Kyle, 2013). That is the difficulty in getting prices of heterogeneous properties and real estate assets where similar transactions are very few and numerous characteristics influencing the property prices. It is even more complex to realize that these properties are rarely traded in the market given that these property transactions are the ones that a valuer relies upon as comparables depending on their level of similarity with the property in question. It is therefore, a matter of fact that constructed facilities are viewed as very valuable assets when exposed in a market environment and this is the key reason for a very small number being traded in the real estate market. Therefore, this makes a valuer's task of attaching a monetary value to such a property in such conditions very challenging.

2.6 Knowledge Gap

The knowledge gap is that macro-economic determinants of construction output have not been thoroughly investigated for purposes of accuracy in policy design for enhanced construction output levels in Kenya. This study therefore endeavors to come up with results which will aid in achieving a better economic growth rate for the sector.

Additionally, the models that have been developed in earlier studies i.e., Kivaa, (2008) have not considered the cointegration of the variables. Therefore, in this study the cointegration has been considered which is leading to better models to inform policy formulation.

2.7 Theoretical Framework

It can be succinctly said that a well sustained construction industry can help raise the standard of living of a country's people as well as lowering the rate of unemployment. However, owing to the fact that many construction projects are usually funded through borrowing from commercial banks, it therefore emerges that CBK's MPC monetary policy has a direct effect on the industry (Cooper & John, 2012). Construction industry is a double-edged sword in a country's economy since it contributes to offering solutions to a number of macroeconomic issues in addition to contributing to the GDP simultaneously.

It is quite clear that a number of queries arise from the macroeconomic perspective as regards to economic behavior of a country. These questions relate to various aspects of a country's economy like its retardation or acceleration, the determination of the level of activity and the production number of goods and services, how job availability numbers are determined and finally, what slows the economy down or speeds its long-term growth. These questions according to various studies can only be responded to from a macroeconomic environment where construction industry comes in handy (College, 2014). This is because a country's macroeconomic health is usually explained through several goals which include the people's growth in relation to their standard of living, low rate of unemployment and low rate of inflation, to mention just but a few. Additionally, the goals can be pursued through the country's fiscal and monetary policies.

From the foregoing, it emerges that construction industry, being a key contributor to the GDP, is usually affected by CBK's Monetary Policy Committee's decisions. All these revolve around macroeconomic theories which explain the levels of GDP change and touch directly on all the factors being investigated in this research. Therefore, the macroeconomic factors that have direct impact on construction output in Kenya according to literature reviewed and especially KNBS reports from 2003 to 2019 include: -

1. Interest rates
2. Inflation rate
3. Exchange rate
4. Population Growth rate
5. Unemployment rate

The theoretical framework is diagrammatically presented in Figure 2.5 below

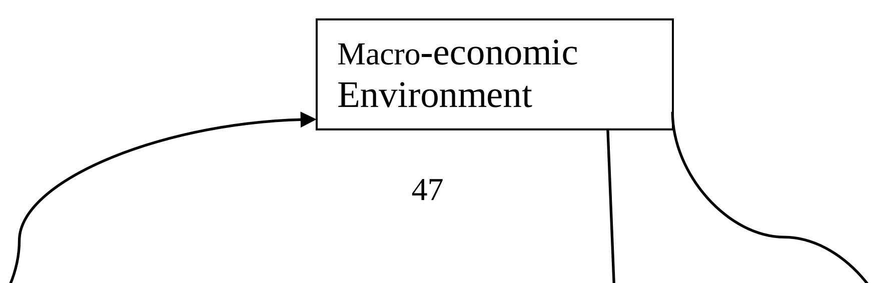


Figure 2.5: Interaction of Construction Output and Macro- Economic Factors

Influences of the above listed macro-economic factors are based on macroeconomic theory. Accordingly, the factors tend to negatively affect construction output through increased costs of construction finances and construction materials. Based on this reason, GDP was excluded as a variable in this study. Further, it was found illogical to regress GDP on construction output which is also a part of the GDP of the country. This study takes a keen look at the link between the macro-economic factors and construction industry output levels in Kenya just as Bickerton & Gruneberg, (2013) did for UK's construction industry output and London Interbank Offered Rate in the year 2013.

2.9 Conceptual Framework

The conceptualization of this research is illustrated in Figure 2.6.

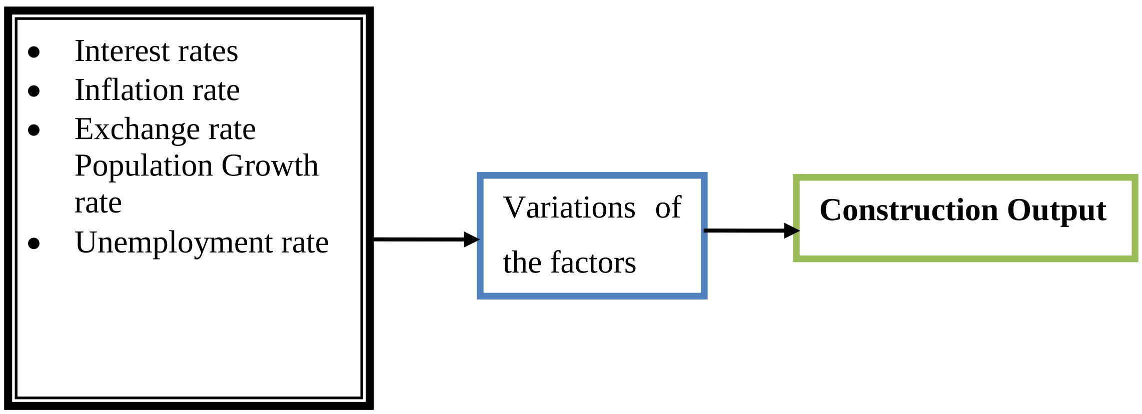


Figure 2.6: The Research Conceptualization

The five independent variables significantly influence Kenya's construction output levels. This means that a change in any of the variables in terms of a decrease/increase is observable on the level of construction output. This change in the level of construction output can either be positive or negative depending on the nature of the specific variable.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The chapter outlines all the steps in the order that was followed in doing the research. The steps describe the philosophical underpinnings, study design, strategy, research instrument which was used in data collection, method of data analysis, the description of the study area and variables in the study.

3.2 Philosophical Underpinnings

The ontological position of assumptions in this study is constructionism, while the epistemological position of the assumptions is positivism. The terms used in explaining the characteristics of philosophical assumptions are ontology and epistemology. Ontology is usually concerned about what is in existence while epistemology is concerned about one's knowledge about something or phenomenon and the extent of knowledge (Vanson, 2014). In this study the unit of analysis is the construction industry of Kenya which is a social organization and therefore a social construction; the constructionist ontological assumption is realistic. Therefore, assumptions of this research study are well grounded philosophically.

According to Bryman, (2012), ontology concerns itself with the nature of entities in the social context. It gives descriptions of two positions namely; positivism and constructionism in social context or even referred to as interpretivism and differentiates them by making reference to two norms; culture and organization which are the most common in social sciences. Bryman, (2012) further explains an organization as an object which is tangible and governed by rules, regulations along with procedures where staff are appointed to various job levels in accordance with labour division, organizational hierarchy and its mission statement and many more. This is quite evident as regards construction industry of Kenya which is the focus of this research study. He further says an organization's reality is external to the people within and portrays social order that requires everyone to act in conformity with the set regulations. Similar to organization, culture is viewed in the same way. It is a bunch of values which are shared within an organization and customs which people conform with after socialization.

Having looked at the Ontological positions of this thesis, the researcher now considers the epistemology of this work. Epistemology is all about information that is viewed as an acceptable knowledge and its acquisition and interpretation. Positivism is adopted in this research and methods have been adopted that are characteristic of the position. Positivism allows no subjective opinions made by the researcher since the approach concentrates on verifiable research observations and relations which are measurable between the observations as opposed to speculation and conjecture. Therefore, the researcher herein is of positivists view due to their inclination towards quantitative research like this one, sighting reliability of such works and the believe that they are more scientific.

3.3 Research Strategy

It is worth noting that research strategies are only three. They are qualitative, quantitative and mixed research strategies. In the case of qualitative research, it is sometimes referred to as exploratory research (Bryman, 2012). It is used to achieve an understanding of underlying reasons, opinions, and various motivations. It provides deep understanding into the actual problem or even assist to come up with ideas or good hypotheses for a good potential in quantitative research like this one.

To achieve the objectives of this study, quantitative data was collected. It is therefore necessary to understand that, quantitative study usually measures what it actually assumes to be a statistical reality in the anticipation of developing universal laws (Maina, 2012). Maina, (2012) farther comes up with a definition that quantitative research is usually an inquiry which delves into identifying a problem, as regards a theory testing, measured with the use of numbers and analysis carried out by way of statistical techniques. In establishing the impact of macro-economic factors on Kenya’s annual construction output levels, the adoption of quantitative research strategy was found to be appropriate due to the quantitative nature of the data involved.

The quantitative research strategy is well explained in Bryman, (2012) saying it is a research approach whereby quantification of data is emphasized in the way it is collected as well as its analysis. The research strategy in accordance with Bryman, (2012) is found to comprise:

- Deductive paradigm with a connection to a study as well as theory whereby emphasis is concentrated on the examination of theories.
- Incorporation of practices including conditions which are in line with natural patterns of study and more specifically those of positivism and finally,
- Exemplification of a common notion certainty which is taken as a non-essential objective truth.

3.4 Research Design

The aim of this research is to answer whether or not, macro-economic factors are helpful policy instruments which can be used to influence Kenya's construction output. Consequently, the study is designed to enable statistical data to be gathered from CBK and KNBS. The data was collected in its raw form and include time series data for construction output, weighted interest rate for commercial banks, rate of inflation, unemployment rate, population growth rate, and Kenya shillings per US dollar exchange rate.

Since the data in this research is ordered by time, the researcher therefore adopts longitudinal study design for the study. One benefit of this design being that the researcher is able to detect at an early stage the developments or changes in the characteristics of the targeted population at both the group and the individual level. The major point here is that longitudinal study goes beyond a single moment in time and hence the reason why it is adopted in this research work. Therefore, a longitudinal study is able to establish a sequence of events. This research design, Bryman, (2012) looks at it as representing a unique kind of research design. He explains this further by saying it is a rarely used design due to time and financial implication. Longitudinal research design according to Bryman, (2012) allows for good deal of insight regarding variables which are time ordered and hence there being a possibility of an allowance to make a causal inference. Bryman, (2012), points out that this design can only be applied in quantitative research and therefore, this research takes into account only quantitative data, which was collected from the two institutions of the government of Kenya. The institutions are mandated by law of the land to compute and compile the statistical data which was collected and used in this study regarding the six variables. Yearly data of the variables were collected and analyzed.

3.5 Targeted Area

This study targeted Kenya as the study area and it touches on one of the country's major economic sectors for purposes of improving its economic performance and hence the performance of the whole economy collectively.

Various reasons have led the researcher into choosing this specific area for this study purpose. Some of the reasons are highlighted and include: -

- The researcher is a Kenyan and a resident in the country.
- The data being sought by the researcher was available to a large extent.
- Most of the data was available publicly in large quantities, hence making it easy for collection.
- The cost of the whole process of data collection was slightly low.
- Time was saved in the whole process due to the reason that he is quite conversant with most of the offices which have the data and due to prompt action by the relevant officers as well.

From the foregoing, the researcher ended up in making great savings in both the costs and time which was very crucial in the process of doing this research.

3.6 Data Collection

This study adopted purely a quantitative strategy and for this reason, quantitative data was obtained from the Central Bank of Kenya (CBK) and Kenya National Bureau of Statistics (KNBS). This is time series data which included data for macro-economic factors and construction output from 1977 up to 2019. Time series method which is also called a random process in discrete time was used to analyze the data. This method as explained in Lapinskas, (2013) involves a sequence of observations that are made and ordered according to their time of outcome.

The KNBS and CBK provided all the data which was required for analysis in this study. The two institutions are the only ones which compute the time series data which was required for analysis in this study.

The data which was collected using a data abstraction sheet or simply data sheet, from the two institutions in its raw form was not consistent with the objectives of this study. The researcher put it in a format to enable analysis with respect to the objectives of this research.

There are quite a number of frequencies at which the time series data can be observed. The commonly used frequencies according to Lapinskas, (2013) include daily, weekly, monthly, quarter yearly, half yearly and yearly. For purposes of this study, the data is ordered yearly in the time domain.

The researcher adopts a data abstraction sheet or just simply a data sheet as a research instrument for the study. Data sheet, like the one appearing in Zaza, *et al.,* (2000) was designed as a standard sheet for statistical data abstraction for any quantitative research. The so-called abstraction form is in form of a booklet containing twenty-six pages which according to Zaza, et al,(2000) is a useful evaluation tool for papers to be published (Zaza, et al., 2000). Data sheet was also used in Kivaa, (2008). This is an indication that data sheet is fairly popular with researchers adopting quantitative strategy.

The data sheet had six columns and each column headed by the name of a variable being investigated. The time series data which was collected in 2019 for this research are mainly rates which make more than 80% of the data. The rest are in Kenya shillings. Therefore, the data sheet is simple in its construction. The data sheet is annexed in the appendix.

3.7 Variables in the Study

This study investigated the macro-economic factors that influence construction output in the country. These factors which were put under investigation are classified as macro-economic factors and are the main variables in this study.

3.7.1 Dependent Variable

The dependent variable in this study is construction output. This is the formal construction output as compiled by the KNBS. The data for this variable was obtained for the period between 1977 and 2019.

3.7.1.1 Construction Output Levels (COt)

This is the total constructed facilities as delivered by the construction sector of any given economy in a given period of time (t), usually a year. This is normally expressed in monetary terms and given as construction GDP in the national accounting system. Its growth can be said to be the quantitative change in construction market value of the constructed facilities produced in a given country per year. Therefore, Gross Domestic Product of construction sector in a country is derived as the net value of all construction or constructed facilities produced in an economy in a particular period of time. In the case of Kenya, this can either be quarterly or annually.

Like all the other constituents of a country's GDP, construction output was based on the 2009 constant prices. This is currently the base year after rebasing was done recently from 2001 constant prices. Constant prices, to put it in the words of (Myers, 2008), is the "monetary value expressed in terms of real purchasing power, using a particular year as the base, or standard of comparison, to allow for price changes. For example, by expressing GDP at constant prices, comparisons can be made over a number of years." Therefore, it is important to note that, at the base year, the index is set at 100 (hundred) and constant prices based on that are usually adjusted for inflation (World Bank, 2009).

3.7.2 Independent Variables

These are the explanatory variables which include macro-economic factors that impact on construction output. The factors are:

- Commercial banks weighted interest rates ($CBWR_t$)
- Exchange rates (ER_t)
- Inflation rate (IR_t)
- Population growth ($POPGR_t$)
- Unemployment rate ($UNEMPR_t$)

The explanatory variables are further explained as follows:

3.7.2.1 Interest rate (CBWRt)

This is the cost of borrowed finances to the borrower (Investopedia, 2017). This study dwells much on commercial banks' weighted interest rate which is the rate used by commercial banks to lend to their clients. Interest rates play a major role in construction and property markets due to their dependency on borrowed finances. The rate of interest that is used by banks to lend to their borrowers is the nominal interest rate. To arrive at this nominal rate, inflation rate is added to real rates of interest (Fernando & Boyle, 2021). Therefore, if inflation rate is subtracted from the nominal interest rate, we get the real rate of interest. It is therefore the nominal rate of interest which the commercial banks adjust to include their profits in order to apply it in their money lending business.

Statistics from CBK show that up to June, 2015, construction sector had borrowed up to 58% of all the funds spend in the sector.

3.7.2.2 Exchange rate (ERt)

This is the worth of a currency in relation to another. The exchange rate behavior of the Kenya's Shilling as compared to the U.S Dollar, are expected to feature in the process of financing construction projects especially from overseas. It is also highly expected by the researcher to have this phenomenon play out strongly on projects which heavily depend on materials which are imported. It is therefore, the intention of the researcher to collect this type of data in order to analyze it for purposes of establishing how it impacts on the output levels of the country's construction industry.

3.7.2.3 Rate of Inflation (IRt)

This is the rate at which generally commodity prices go up within an economy as mostly indicated by the CPI (Consumer Price Index). The inflation is usually taken as the change in percentage of the Consumer Price Index in a country over a single year period. The impact it has on construction output is that, when the prices of major commodities go up, for instance cement prices, the construction industry delivery may drop due to high-cost factor. As well, whenever essential commodities prices go up, people mostly tend to embark on meeting essential needs and hence stop the thought of investing in industries such as construction because of the huge investment outlay involved because of probably the heightened inflation rate.

This could be viewed as an important reason why rate of inflation is a major monetary policy focus of the MPC (Monetary Policy Committee) of the Kenya's central bank to maintain it as low as practicable and keep stabilized prices in the economy.

The Government via the CBK fixed the overall medium-term maximum target of inflation as 5%. This was set for 2015/2016 fiscal year to allow for a margin of plus or minus 2.5 percent. This is somehow achievable since the rate has been hovering around 7% in 2017.

3.7.2.4 Unemployment rate (UNEMPRt)

In a country, a picture of labour force, is usually clear when one views it as the employed alongside the self-employed and unemployed. This according to SNA where it is further said that, a person who is unemployed is neither an employee or self-employed, but is a person available for any work and is actively searching for some form of employment/work. The concept of unemployment is usually not necessary since the national accounts require the employed who contribute to production; the population that is economically active (World Bank, 2009). Therefore, the percentage of the unemployed in Kenya is the variable the researcher included in the research.

This is a major problem not only in Kenya today but also in all developing countries of the world. Kenya National Bureau of Statistics explains unemployment rate as a measure of the number of people who are actively looking for jobs as a percentage of the whole labour force in the country. Unemployment Rate in Kenya is said to have increased up to 40 percent in 2011 as compared to 12.70 percent in 2006. This unemployment rate in the country has averaged 22.43 percent beginning from 1999 up to 2011. It reached an all-time high of 40 percent in 2011 and it recorded a low of 12.70 percent in 2006. Similar details are also seen in different quarters (Economics, 2016). It is also said in Akintoye & Skitmore, (1991) that other factors which are said to affect construction investment levels are unemployment and seasonality in many countries. A reducing rate of growth of the employment and the resulting increase in unemployment may discourage investment in construction, as this has a direct connection with the whole purchasing power of the general population in a country.

3.7.2.5 Population Growth rate (POPGRt)

Population is a term which is commonly used in day today life. Therefore, it is important to put it in the right perspective as regards this research. A country's population is in simple terms mostly defined in the system of national accounting (SNA) as all the people/persons who are normally resident within the same country (World Bank, 2009). This is important to note since one may look at it from a different perspective.

Kenya's population according to KNBS and Economics, (2016) is 44 million. This population represents 0.60 percent of the current world´s total population and it can be argued that every one person in every 168 people on the planet is said to be a resident of Kenya (Economics, 2016). As at 7th May, 2019, the population stood at 52million representing 0.68% of the world population. The huge number in population requires shelter as one of the basic needs as seen in Maslow's hierarchy of needs. While fulfilling this need, the researcher intends to find out whether it also impacts on the construction output as well.

The conceptual and operational definitions of the variables are given in table 3.1.

Table 3.1: Conceptual Definition and Measure of Variables

Description of the Variable	Symbol of the Variable	Conceptual Definition	Operational Definition
Construction output	CO	Construction GDP	Kenya shillings
Commercial Banks Weighted Interest Rate	CBWR	The rate used by Commercial banks to lend money to their Customers	Percentage (%)
Exchange Rate	ER	The amount at which the shilling exchanges to the dollar	Kenya shilling (Kshs.) per US. Dollar
Inflation Rate	I R	The average rate at which prices rise	Percentage (%)
Population Growth	POPGR	Total No. of People	Percentage
Unemployment Rate	UNEMPR	In the country Unemployed People	Percentage

3.8 Data Analysis

Time series analysis embraces the methods applied for the analysis of time series data for purposes of extracting meaningful data characteristics and other statistics. In this research, there is only one type of data collected. This is quantitative data from Kenya National Bureau of Statistics (KNBS) and Central Bank of Kenya (CBK). The quantitative data was collected using data sheets and analyzed using time series analysis method.

3.8.1 Time Series

A time series is said to be a sequence whose index corresponds to consecutive dates which are separated by an interval of a unit time (Pollock, 1999). Therefore, a sequence is usually said to be a function mapping from a set of integers, which are described as the index set, onto the real line or into a subset thereof. All said and done, time series is simply a sequence of numerical data points in successive order (Pollock, 1999). In addition, Gujarati & Porter, (2009) define it in a similar way that, it is a set of observations on the values that a variable obtains at diverse times. All the variables in this study are time series and hence time series data is utilized throughout the study.

3.8.2 Time Series Data Analysis

In the process of statistical analysis of time series data, the elements of the sequence are taken as random variables sets. Frequently, no notational distinction is allowed in between these random variables together with their realized values. However, it is mainly important to bear the distinction at the back of one's mind (Pollock, 1999).

Pollock, (1999), asserts that, in the analysis of a statistical time series, an assumption has to be made that the structure of the statistical or the stochastic process involved in generating the observations is fundamentally invariant through time. The conventional assumptions, as he further explains, are summarized in the stationarity condition. In its well-built form, the condition necessitates that, any two segments of the same length which are extracted from the time series, must have indistinguishable functions of multivariate probability density. Still, the fragile stationarity condition has a requirement of only that the elements of the time series must have a similar finite expected value and that the auto covariance of two elements should only depend on their separation temporarily (Gujarati & Porter, 2009) and (Pollock, 1999).

An elementary process, from which many other stationary processes maybe derivatives, is the so-called white-noise process which has a sequence of random variables which are uncorrelated, with each having a zero mean and equal finite variance. If the white noise is passed through a linear filter, this can lead to the generation of a sequence whose elements are serially correlated (Pollock, 1999). It is therefore imperative to ensure time series data passes the stationarity test before any other tests and the researcher takes this seriously for purposes of obtaining reliable results in this research.

3.8.3 Time Series Data Analysis Procedure

Time series data analysis method is the only one which could be used for time series data such as the ones in this study. This is secondary data since it is collected from institutions which compute and store the data as required in this research. The procedure which was followed involved entering the data into a computer using Microsoft office Excel 2007 software and then opening it from Economic Views (Eviews version 10) software as a foreign data which was eventually turned into an Eviews work file. The time series data was first checked for stationarity and since most economic data are usually nonstationary as seen in Gujarati and Porter, (2009), they were consequently transformed into stationary ones to avoid spurious or nonsensical regression. It is generally assumed that all-time series data used for empirical work is stationary as is found in Gujarati and Porter, (2009). It is therefore quite essential according to Gujarati and Porter, (2009) to establish whether the relationship among economic variables is nonsensical or spurious. A very high R^2 values are an indication of this phenomenon.

Logarithmic plot of construction output and ordinary plots of all the macro-economic factors were done. Logarithmic transformation of the construction output data was necessary to reduce the problem of heteroscedasticity (Gujarati & Porter, 2009). Heteroscedasticity checks indicated the series which were homoscedastic and hence plotted without logarithmic transformation and this was the case for all the five macro-economic factors. The plots were done to observe the trend of all the series which implies non-stationarity of the time series data. After the observation of the plot behaviors/trend component, the researcher made a decision to apply the first differences or second differences to make the data stationary. Stationarity was exhibited by a graph which had no trend.

Autocorrelation functions (ACF) and Correlogram tests were also carried out for purposes of comparison with the graphical analysis so as to confirm the nonstationarity condition.

Unit root stationarity test which is the most authoritative test was finally conducted. This test method is also called the Augmented Dickey-Fuller (ADF) unit root test in honour of Dickey and Fuller who developed it (Gujarati & Porter, 2009). It is among the best tests since it augments two methods which were initially developed by the duo (Gujarati & Porter, 2009). The method was used to test the data before and after differencing to ensure complete stationarity. The method tested the hypothesis that "the variable has a unit root." The presence of a unit root means the data of a particular variable were nonstationary. The test was carried out at $\alpha = 0.05$ confidence level.

3.8.4 Multiple Regression Model

This is a single equation model depicting the relationship between the macro-economic factors and construction output in Kenya. A set of a mathematical equation is simply referred to as a model (Gujarati & Porter, 2009). Therefore, a mathematical equation is formulated in this research depicting the relationship of the variables.

After ensuring that all the time series data were stationary, multiple regressions was carried out where construction output was regressed on all the explanatory variables. The regression model which was used in this analysis is: -

$$\mathbf{CO_t = \alpha + \beta_1 CBWR_t + \beta_2 IR_t + \beta_3 ER_t + \beta_4 UNEMPR_t + \beta_5 POPGR_t + \varepsilon_t} \quad \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(2)}$$

Where:

$\mathbf{CO_t}$ = Construction Output in a specific Time

$\mathbf{UNEMPR_t}$ = Unemployment rate at any specific time

$\mathbf{CBWR_t}$ = Commercial Bank' Weighted Interest Rates in a specific Time

$\mathbf{POPGR_t}$ = Population growth rate at a specific time

$\mathbf{IR_t}$ = Inflation Rates in a specific Time

$\mathbf{ER_t}$ = Kenya shilling per US dollar Exchange Rate in a specific Time

$\boldsymbol{\beta}$ = Regression Coefficient

$\boldsymbol{\varepsilon}$ = Error Term or Residual

α **=** Intercept (this is the value of CO_t when explanatory variables are set at zero)

The null hypothesis was H_0: $\beta_i = 0$

The research hypothesis was H_1: $\beta_i \neq 0$ for at least one coefficient β

Construction output (CO) was regressed on the explanatory variables, applying the first difference of all macro-economic factors except construction output (CO) whose natural logarithms of the first differences were used. The ordinary least squares (OLS) method was used in the time series regression analysis.

3.8.5 Nonlinear Modeling

This was aimed at establishing if the macro-economic variables had some nonlinear relationships with construction output in Kenya. In this case two nonlinear methods of modeling construction output were used. The methods were quadratic and exponential regression modeling. This regression modeling of construction output was explored to find out if there existed a nonlinear relationship between the macro-economic factors and construction output in the country. The functions used for these explorations were all linear - in - parameters but nonlinear-in-variables.

3.8.5.1 Quadratic Regression modeling

The general form of this regression modeling takes the form:

$$\mathbf{Y = \alpha + \beta_1 X + \beta_2 X^2 + \varepsilon} \qquad \textbf{(3)}$$

Where,

Y = Dependent variable

X = Explanatory variable

α = Intercept

β = Coefficients

ε = Error term

Specific to this study, the following quadratic regression model was applied to regress construction output on all the macro-economic variables.

$$CO_t = \alpha + \beta_1 X_t + \beta_2 X_t^2 + \varepsilon_t \qquad (4)$$

Where,

CO_t = Construction output

X_t = Macro-economic factor at a specific time

α, β = parameters

ε = Error term

For purposes of satisfying the stationarity condition in this process, the first differences of the logarithms of construction output CO_t and the first differences of the macro-economic factors were used in this modeling.

The null hypothesis for the quadratic modeling was H_0: $\beta_i = 0$

The research hypothesis was H_1: $\beta_i \neq 0$ for at least one coefficient β

3.8.5.2 Exponential Regression modeling

In general, an exponential function or model which depicts a nonlinear relationship takes the form:

$$Y_t = e^{\beta 1 + \beta 2Xt + \beta 3Xt} \quad \textbf{……………………………………………………………… (5)}$$

Where,

Y_t = Dependent Variable at a given year

X = Independent variables

β = Regression coefficients

t = A given time period

e = Constant (Euler's number)

As regards this research thesis, the five (5) macro-economic variables and the dependent variable were put together to form an exponential regression model as formulated below.

$$CO_t = e^{\alpha + \beta 1(CBWRt) + \beta 2(IRt) + \beta 3(ERt) + \beta 4(UNEMPRt) + \beta 5(POPGRt) + \varepsilon t} \ldots\ldots\ldots$$

(6)

Where:

CO_t	=	construction output
$UNEMPR_t$	=	Unemployment rate at any specific time
$CBWR_t$	=	Commercial Bank' Weighted Interest Rates in a specific Time
$POPGR_t$	=	Population growth rate at a specific time
IR_t	=	Inflation Rates in a specific Time
ER_t	=	Kenya shilling per US dollar Exchange Rate in a specific Time
β	=	Regression Coefficient
ε	=	Error Term or Residual

α = Intercept (this is the value of CO_t when explanatory variables are set at zero)

e = Constant (Euler's number)

The first differences of the logarithms of construction output CO_t and the first differences of the macro-economic factors were used in this modeling process to satisfy the stationarity condition.

The null hypothesis for the exponential modeling wasH_0: $\beta_i = 0$

The research hypothesis was H_1: $\beta_i \neq 0$ for at least one coefficient β

3.8.6 Dynamic Modeling of Construction Output

Due to cointegration of the economic variables in this study, it was necessary to go one step further in the data analysis. As observed in Gujarati & Porter, (2009), vector auto-regressive (VAR) modeling was carried out using variables which were integrated of order one I(1). Therefore, the variables which were integrated of order two I(2) could not be included in the modeling process. In this case, population growth was left out in this modeling.

In the VAR modeling, all variables were treated as endogenous variables since there are usually no exogenous variables in this form of modeling of time series variables. Since the variables in a vector autoregressive model must fulfill the condition of being integrated of order one I(1), only five variables qualified in this research. The five were construction output, commercial banks weighted interest rates, US to Kenya Shillings exchange rate, inflation rate and unemployment rate. They were subjected to cointegration test to confirm this condition.

The Johansen cointegration test used in this test converts the data of the time series to their first differences automatically (Granger & Watson, 1984). Otherwise, the test results may not be accurate. Presence of cointegration amongst the variables leads to application of correction measures to remove the long-term association of the variables. In this case, vector error correction model (VECM) was formulated and used. Generally, the term vector is used because of the several number of variables in this research and it is auto-regressive due to inclusion of lagged dependent variable on the right-hand side of the model as observed in the following general dynamic expression: -

$$\mathbf{Y_t = \alpha + \Sigma\beta_{ji}X_{t,t-1} + \gamma Y_{t-1} + \varepsilon_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \mathbf{(7)}$$

Where:

α, β_i and γ are parameters ($\beta_j \neq 0$) Xi, t-I $Y_{i,\ t-1}$ are selected lags of the five explanatory variables and ε_t is an error term.

The following was the restricted vector error correction model (VECM) which was used in this research for the dynamic modeling: -

$$\mathbf{Logco_t = \alpha + \sum_{i=1}^{k}\beta_i Logco_{t-1} + \sum_{j=1}^{k}\Phi_j CBWR_{t-j} + \sum_{m=1}^{k}\omega_m IR_{t-m} + \sum_{p=1}^{k}\delta_p ER_{t-p} + \sum_{q=1}^{k}\Theta_q UNEMPR_{t-q} + \varepsilon_t}$$

$$\ldots\ldots\ldots\mathbf{(8)}$$

The model consists of five (5) variables which are all treated as endogenous variables. It is important to note once again that in VAR modeling there are no exogenous variables (Gujarati & Porter, 2009) and (Wooldridge, 2013). Therefore, all variables are endogenous variables.

3.8.7 ARIMA Model

ARIMA models have recently been used in a number of researches for purposes of forecasting output of different sectors in the construction industry of different countries in the world. Examples are (Akintoye & Skitmore, 1994), (Bickerton & Grunerberg, 2013) (Notman, Norman, Flanagan, & Agapiou, 1998) who studied this industry in the UK and (Hua & Pin, 2000) who studied the industry in Singapore. Therefore, this is just to point out how there is growing interest to apply this method in the study of a country's construction industry. An ARIMA model is usually a univariate or a single vector model (Gujarati & Porter, 2009). It is a technique mostly used for forecasting and projecting future values of a time series on the basis of its own inertia. It has been seen that it performs much better if applied on forecasts which are short term; at least around forty (40) points of historical data (Morrison, 2020). According to Morrison, (2020), researchers are better adopting other methods if their data points are below thirty-eight (38). Based on this argument, it can therefore be said that the data collected and analyzed in this research is adequate.

From the forgoing, Kenya's construction output is viewed from that perspective. That implies to establish whether the construction output is a self – projecting variable. This further implies that construction industry's annual output in any one given year is influenced by its output of the past years and stochastic error terms. To establish this, an ARIMA (Autoregressive Integrated Moving Average) regression was carried out using the following model:

$$CO_t = \theta + \alpha_1 CO_{t-1} + \alpha_2 CO_{t-2} + \ldots\ldots + \alpha_p CO_{t-p} + \beta_0 \mu_t + \beta_1 \mu_{t-1} + \beta_2 \mu_{t-2} + \ldots + \beta_q \mu_{t-q} \quad (9)$$

Where:

θ = represents a constant term

p = the number of autoregressive terms

q = the number of moving average terms,

μ_t = unautocorrelated random error term with zero mean and constant variance (σ^2).

At this point, the level of output (CO) at time t depends on its level in the previous p time periods (years), and on the moving average of the current and past q error terms.

From the multiple regression model, annual construction output was explained by macro-economic factors. This has an implication that construction output is influenced by a number of factors. These macro-economic factors are Unemployment Rate at any specific time, Commercial Bank' Weighted Interest Rates in a specific time, Population growth rate at a specific time, Inflation Rate in a specific year and Kenya shilling per US dollar Exchange Rate in a specific year. Therefore, Construction Output at time t (CO_t) was expressed as a function of these macro-economic variables, as follows: -

$CO_t = \alpha + \Sigma\beta_{ji}X_{jt-i} + \varepsilon_t$ ………………………………………………………………….. (10)

Where:

α and β_i are the parameters ($\beta_{ji}\neq0$), $X_{i,\ t-I}$ representing selected lags of all the explanatory variables. ε_t is a random error term, having a zero mean and a variance of σ^2.

The accuracy of both the Autoregressive Integrated Moving Average (ARIMA) and the multiple regression (MR) models were evaluated using their R^2values, their mean absolute percentage error (MAPE), mean percentage error (MPE),) and root mean square error (RMSE). The first forty observations were used as the modeling data whereas the last three (3) were used for testing the models for forecasting accuracy. This method of time-series analysis (ARIMA) was initially developed by Box and Jenkins in 1976 and has become popularly known as the Box-Jenkins approach (Hua & Pin, 2000). It was therefore applied in this research for data analysis.

Notman, et al. (1998) and Hua & Pin, (2000) serve as adequate examples of time series analysis for UK construction output data and Singapore respectively. The researcher adopted this method in carrying out an in-depth study of the mentioned five (5) macro-economic factors with an endeavor of establishing their effects on construction output levels in Kenya. This being an area of concern by the government where it intends to grow the economy by double digits, the findings of the study shall go a long way in promoting this notion by the government in the achievement of vision 2030 and the big four agenda.

3.9 Ethical Considerations

The considerations concerning ethics were properly accounted for in this research in the manner in which this work was done. Firstly, the university (JKUAT) introduced the researcher (me) to National Commission of Science, Technology and Innovation (NACOSTI). This assisted me in the acquisition of research permit which is an authorization by the government to carry out this research activity. The two documents are shown in appendix A and B respectively.

Secondly, the data which was collected and analyzed in this research was exactly as was obtained from the KNBS and CBK. Finally, verification of all the references as they appear in this research was done by the researcher and it is confirmed that they are as reported in this research.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

4.1 Introduction

This chapter is a presentation of how results were obtained through the application of the methodology as laid down in the previous chapter. The time series data analysis methods were carefully followed from the start up to the end of the analysis process and this led to the achievement of reliable results. The time series data analysis process involved graphical analysis which is always the first step in any time series data analysis process. This type of analysis which lies squarely on the first objective involves plotting graphs of all the variables and close inspection of their behavior. This was followed by stationarity tests and eventual transformation for all the variables to achieve the stationarity. Once this process was completed, correlation analysis followed and all the independent variables were correlated with the dependent variable; construction output (CO). Regression data analysis followed after the correlation analysis and models for describing and forecasting construction output were eventually developed.

4.2 The Data Collected

Data for this research was obtained from KNBS and CBK for the period between 1977 and 2019. This translates to forty – three (43) years of data points which was adequate for analysis. The researcher had earlier targeted collection of data from 1963 but KNBS advised otherwise due to unavailability of accurate historical records. The data collection process was carried out for seven (7) variables. The variables included construction output (CO), commercial banks weighted interest rate (CBWR), central bank rate (CBR), inflation rate (IR), US Dollar to Kenya Shillings (USD/KSHS) exchange rate (ER), Kenya's unemployment rate (UNEMPR) and Kenya's population growth rate (POPGR). One variable (CBR) was later dropped along the way after realizing its data sets were available from 2007 to 2019. This was only 13 years and could not be analyzed along other remaining variables. It is also important to note at this point that all the data for all the variables in this research were collected on annual basis; 1977 to 2019. If compared with Kivaa, (2008) - forty years and Bickerton & Gruneberg, (2013) – eighteen years, the series herein are a bit longer.

The current base year in Kenya is 2009. This is in accordance with SNA, (2008) which require nations of the world to carry out rebasing process from time to time. In Kenya, this is usually done after around eight (8) to ten (10) years. Therefore, the data for construction output is in 2009 prices. This fresh data is available in appendix D alongside all the variables analyzed in this research. The data was collected using a data sheet or checklist which can also be viewed from appendix C.

4.3 Graphical Analysis

The data was graphically analyzed by first plotting it on graphs. As indicated in Gujarati and Porter, (2009), this is usually the first step in time series data analysis for purposes of observing the presence of time series data components. According to Gerbing, (2016), these components could be trend which may be either increasing or decreasing. The other component which was assessed was the cyclical component to establish whether it was irregular and the lengths of its swings. Seasonality is usually a concern in time series data analysis but this was not displayed in the data collected.

All the variables were plotted and observations made with regard to time series data components. The variables which were displaying heteroscedasticity were considered for logarithmic transformation which led to homoscedasticity of the variable's data. Only one variable required this transformation and it was construction output. The rest of the variables were homoscedastic and did not require this transformation. They included the following:

1) 1nflation rate
2) Exchange rates

3) Population growth rate
4) Commercial bank weighted interest rate
5) Unemployment rate

The ordinary and logarithmic transformation (e^x) plots are further described using

the given figures from 4.1 to 4.6

4.3.1 Construction Output

The upward trend component is quite visible in this variable as observed in figure 4.1 below. Though in the early years; 1977 up to around 1991 it appears the industry in Kenya was almost stagnant. It started picking up very slowly from the 1990s on wards though with fluctuations. This is not an ideal behavior of a construction industry of a developing country where a steady growth is highly expected (Bon, 1992). Therefore, from the observations made from this figure, the construction industry is not performing as expected.

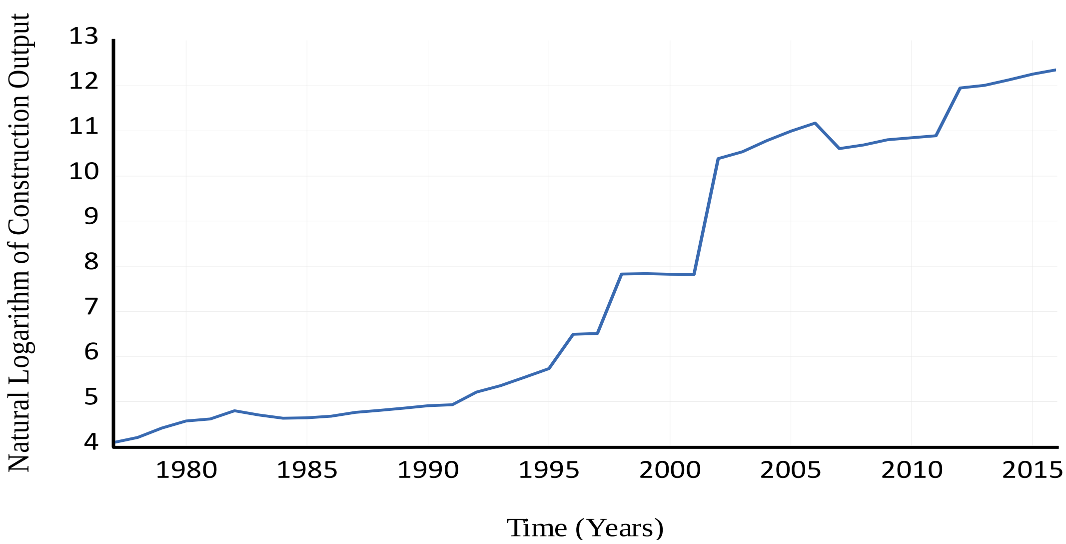


Figure 4.1: Logarithm of Construction Output (2009 Kshs.) 1977 – 2016

4.3.2 Population Growth Rate

This variable presents a decreasing trend from 1983 up to around 2002. This is in conformity to the government's campaigns to keep the population growth rate to minimum. It can be observed that over ninety percent (90%) of the entire period under consideration, the trend is declining at a fairly good rate. The time between 1977 and 1982 is the only period observed to display an ascending order of the population growth rate. See figure 4.2 overleaf.

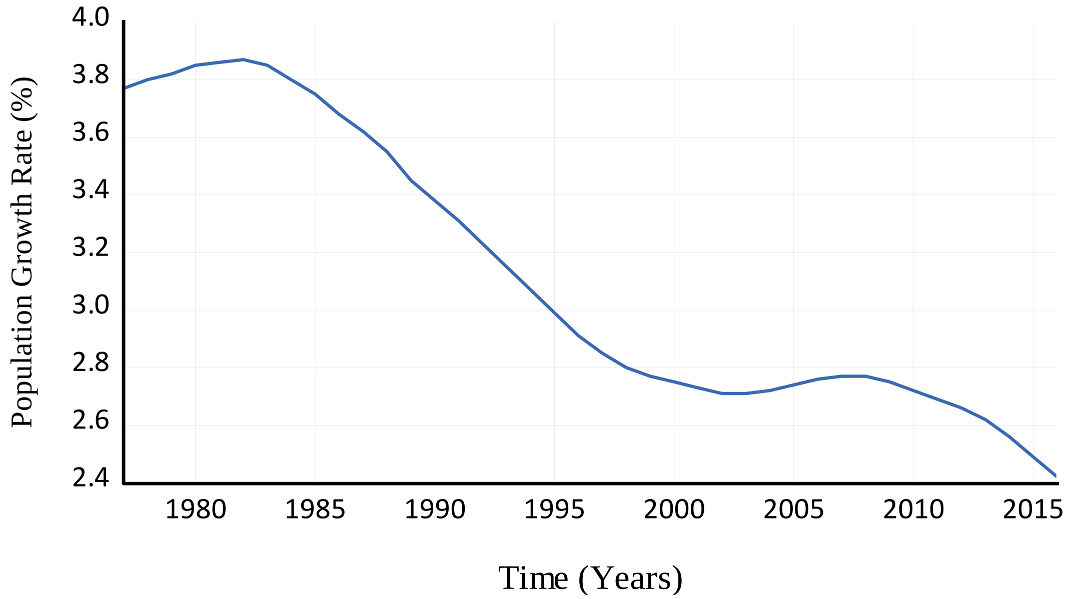


Figure 4.2: Population Growth Rate

4.3.3 Unemployment Rate

Unemployment rate is one of the major macro-economic factors that the government is concerning itself with. Looking at the initial years under consideration in this study, unemployment rate appears to be decreasing. This is especially the period between 1977 and 1989 as observed from figure 4.3. From this figure, it is further observed that the rate rose slightly between 1989 and 1990 and then took a sharp decline in 1991. Since 1991, this rate has been going up and approached almost 10% in 2013.

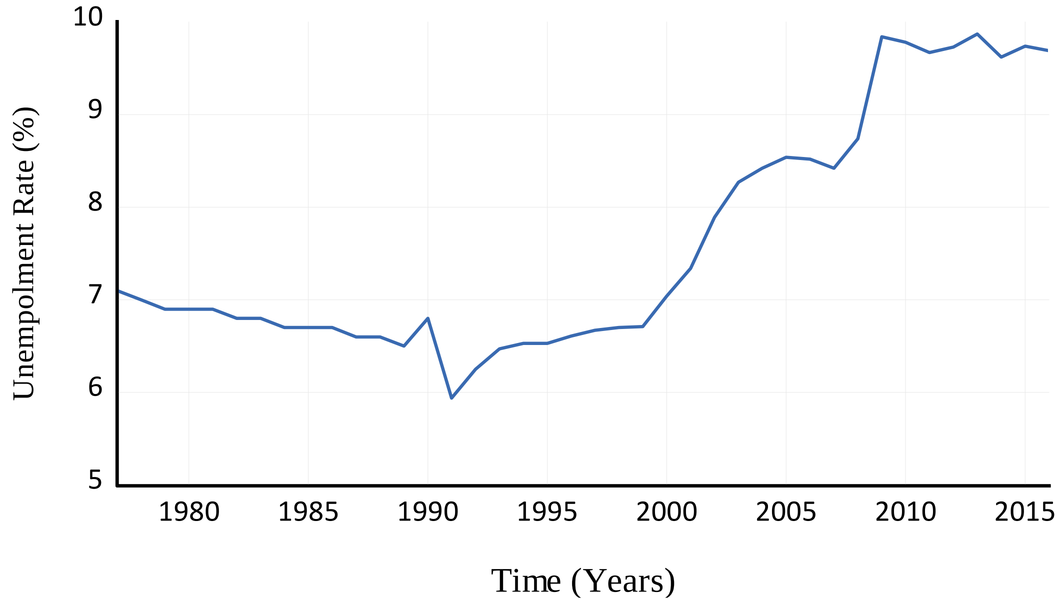


Figure 4.3: Unemployment Rate

4.3.4 Commercial Banks Weighted Interest Rate

Interest rates in Kenya have been rising at an alarming rate from 1977 to 1994 when it reached its highest rate of 36.2%. The trend began to change after 1994 when it changed from an increasing trend to a decreasing one. This continued for period of ten (10) years from 1994 to 2004. Since then, the highest recorded figure was 19.7% in 2012. Interest rates capping of 2016 looks like, it helped to keep down this rate since it has been dropping, though slightly, from that year. See Figure 4.4.

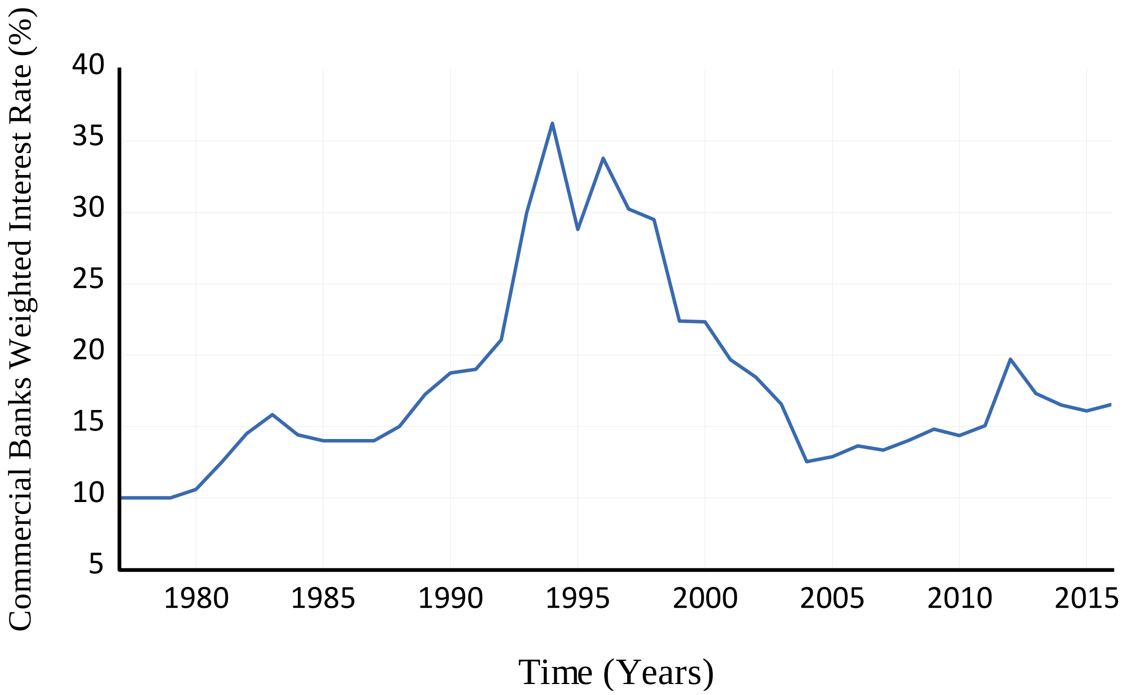


Figure 4.4: Commercial Banks Weighted Interest Rate

4.3.5 Inflation Rate

The inflation rate in Kenya has been averagely above ten (10%) percent over the forty-three years. This is observed in figure 4.5. With reference to this figure, the highest recorded rate of inflation within the period under consideration is forty- six (46%) which was recorded in 1993. Generally, this variable is observed to fluctuate so much throughout the period under consideration that is 1977 to 2019. It reached its lowest in 1995 when it recorded an all-time low of two (2%) percent.

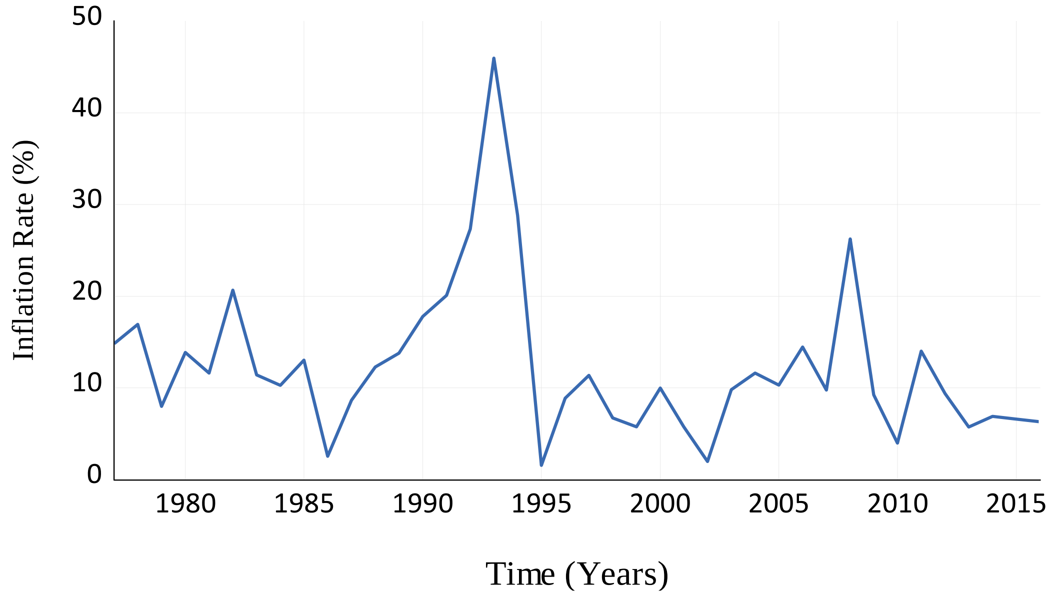


Figure 4.5: Inflation Rate

4.3.6 Kenya Shillings to US Dollar Exchange Rate

The cost of the US dollar has been rising steadily and moderately from 1977 to 2019 which is the period under study. The movement of the dollar rate went up from Kshs. 8.00 in 1977 to Kshs. 102.00 in 2019. The highest this rate has ever recorded within this period is Kshs.103.00 in 2017 and the lowest remains Kshs.8.00 in 1977. See Figure 4.6.

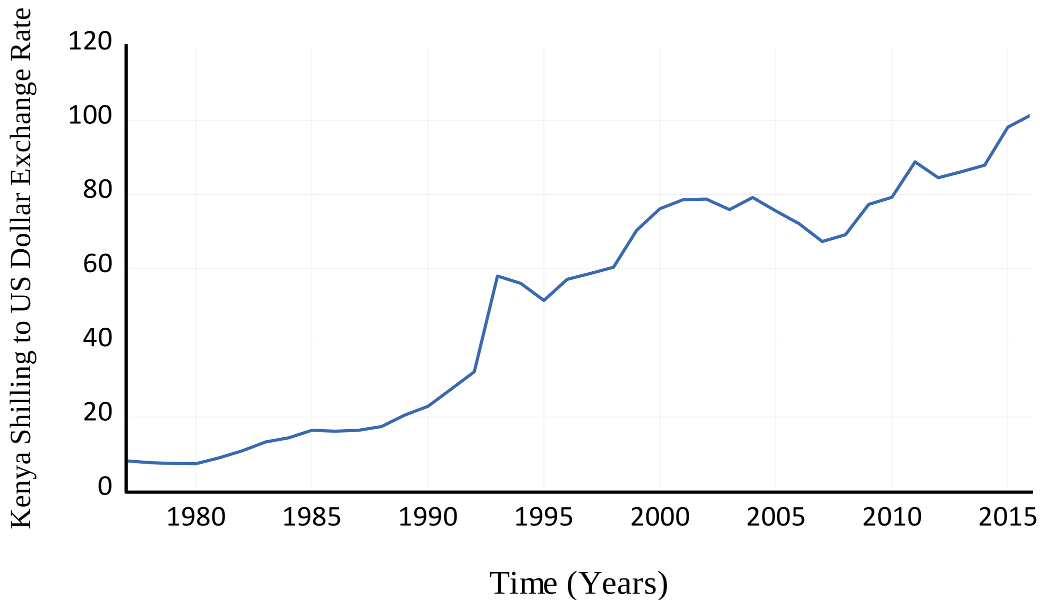


Figure 4.6: Exchange Rate

4.4 Data Stationarity Tests

High importance is attached to this test for time series data. The main reason for regarding this test as important is that, unstationarity mostly leads to unreliable results. With regard to this, the researcher chose to carry out three (3) main stationarity tests to ensure the chances of spurious regression results are highly kept to minimal. The tests which were carried out on the time series data for this purpose were differencing, correlogram and finally the unit root test and therefore, this ensured no little chance was left for arriving at results which are unreliable. This process and its importance are highlighted by a number of writers including Cryer & Chan, (2008), Granger & Watson, (1984) and Gujarati & Porter, (2009) just to mention but a few of these econometric experts who say the process should precede any other tests in time series data analysis. Therefore, the six economic time series variables in this research were firstly subjected to this stationarity test process before any other form of analysis. The variables which were found to be nonstationary were then transformed to stationarity. It is widely agreed in econometric circles that most economic time series data are nonstationary and their first differences are stationary.

4.4.1 Construction Output

The variable presented heteroscedasticity problem and therefore it was necessary to carry out logarithmic transformation in order to minimize the problem. The application of the first differences of the logarithm of construction output time series data was found to be a stationary process. These results are presented in the figure below.

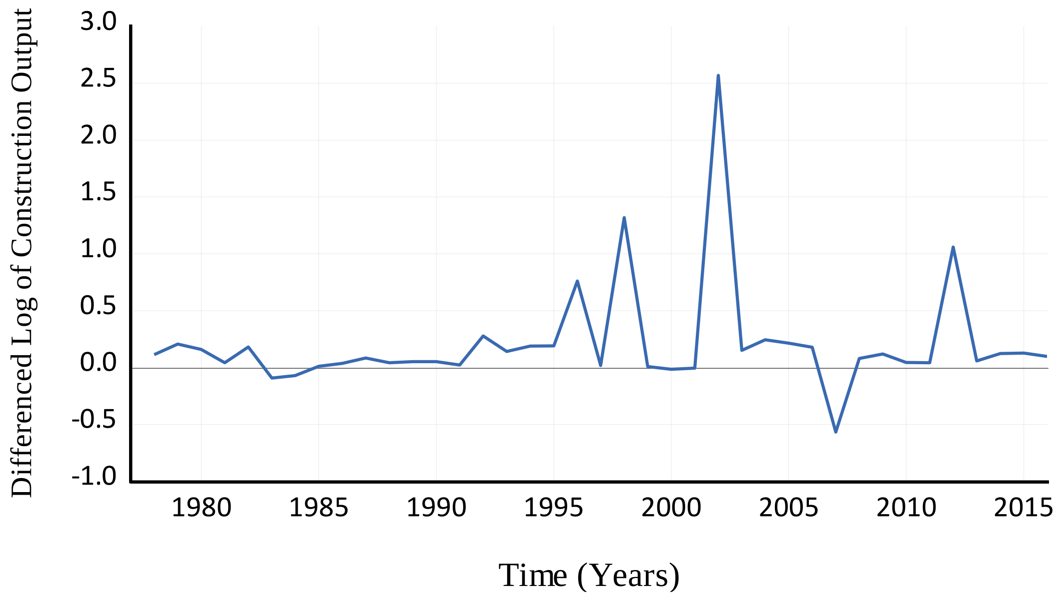


Figure 4.7: Differenced Natural Logarithm of Construction Output

Construction output in Kenya indicated stationarity after subjecting its data to both correlogram and unit root tests. The first differences were stationary. This can be observed from table 4.1 in the columns labeled "Autocorrelation" and "AC" where all the values are observed to be tending towards zero. In the case of the unit root test, the null hypothesis that construction output has a unit root was rejected. This is observed in table 4.2 which presents the unit root test results.

Table 4.1: Correlogram of First Differences of Construction Output

Sample: 1977 2016
Included observations: 39

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.094	0.094	0.3692	0.543
		2	0.153	0.145	1.3795	0.502
		3	0.190	0.169	2.9778	0.395
		4	0.148	0.108	3.9808	0.409
		5	-0.324	-0.415	8.9184	0.112
		6	0.065	0.058	9.1252	0.167
		7	0.039	0.128	9.2023	0.238
		8	0.020	0.151	9.2240	0.324
		9	-0.003	0.042	9.2243	0.417
		10	0.240	0.028	12.402	0.259
		11	0.012	-0.046	12.411	0.334
		12	0.023	-0.017	12.441	0.411
		13	0.015	-0.003	12.455	0.491
		14	0.011	-0.018	12.463	0.569
		15	-0.041	0.094	12.576	0.635
		16	-0.040	-0.074	12.685	0.696

Table 4.2: Unit Root Test for First Differences of Construction Output

Null Hypothesis: D(CO) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 4 (Automatic - based on SIC, max. lag=9)

		t-Statistic	**Prob.***
Augmented Dickey-Fuller test statistic		-13.16401	0.0000
Test critical values:	1% level	-4.252879	
	5% level	-3.548490	
	10% level	-3.207094	

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

Augmented Dickey-Fuller unit root test method was used for this variable and the null hypothesis was rejected at 95% confidence interval. This assured the researcher that further analysis can be carried out using the first differences of this variable.

4.4.2 Unemployment Rate

This variable appeared to be stationary after taking the first differences. The results which confirm this status are presented in figure 4.8.

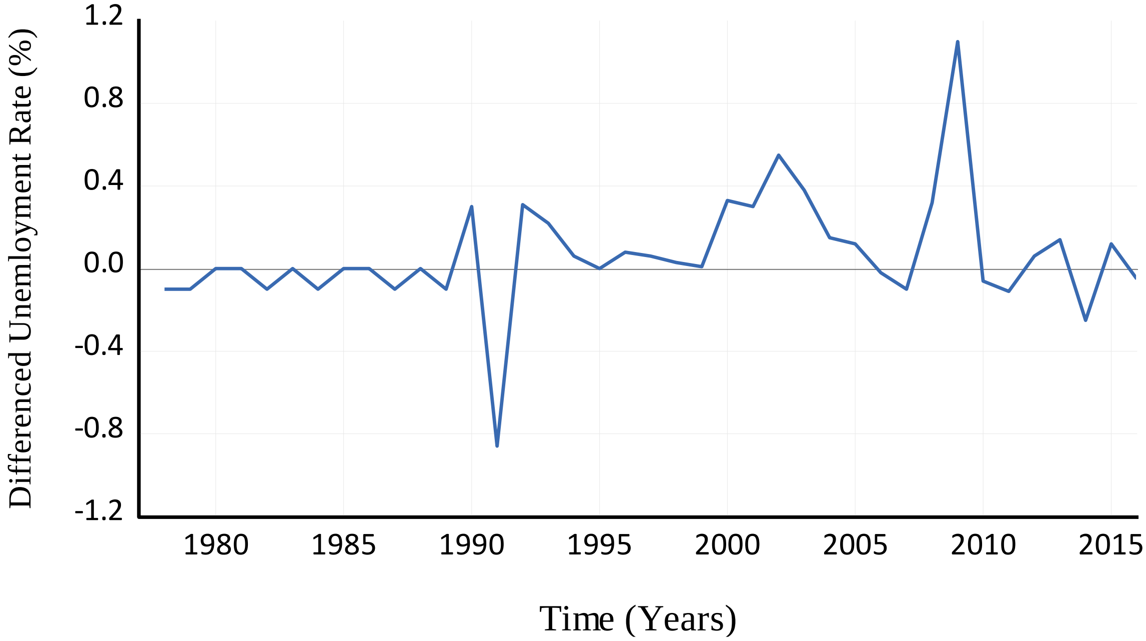


Figure 4.8: First Difference of Unemployment Rate

The correlogram of unemployment rate in Kenya indicated that the variable's first differences were stationary. Results of this test are presented in table 4.3 overleaf.

Table 4.3: Correlogram of First Differences of Unemployment Rate

Date: 08/05/20 Time: 16:52
Sample: 1977 2016
Included observations: 39

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.094	-0.094	0.3706	0.543
		2	0.026	0.018	0.4008	0.818
		3	-0.054	-0.050	0.5296	0.912
		4	0.299	0.292	4.6026	0.331
		5	-0.328	-0.306	9.6505	0.086
		6	0.173	0.170	11.097	0.085
		7	-0.009	0.012	11.101	0.134
		8	-0.024	-0.155	11.132	0.194
		9	-0.152	0.064	12.357	0.194
		10	0.238	0.058	15.489	0.115
		11	-0.165	-0.120	17.042	0.107
		12	-0.120	-0.098	17.898	0.119
		13	-0.117	-0.151	18.739	0.131
		14	0.019	-0.107	18.763	0.174
		15	-0.106	0.086	19.505	0.192
		16	0.035	-0.052	19.592	0.239

Unemployment rate had no unit root, an indication that the first differences were stationary for this variable. The null hypothesis that it had a unit root was rejected. These results are as shown in table 4.4 below.

Table 4.4: Unit Root Test for the First Difference of Unemployment Rate

Null Hypothesis: D(UNEMPR) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, max. lag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.084717	0.0001
Test critical values:	1% level	-4.219126	
	5% level	-3.533083	
	10% level	-3.198312	

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

4.4.3 Population Growth Rate

The second differences were stationary for this variable. This means that the data had to bedifferenced twice to achieve the stationarity. The graph given in figure 4.9 displays these results.

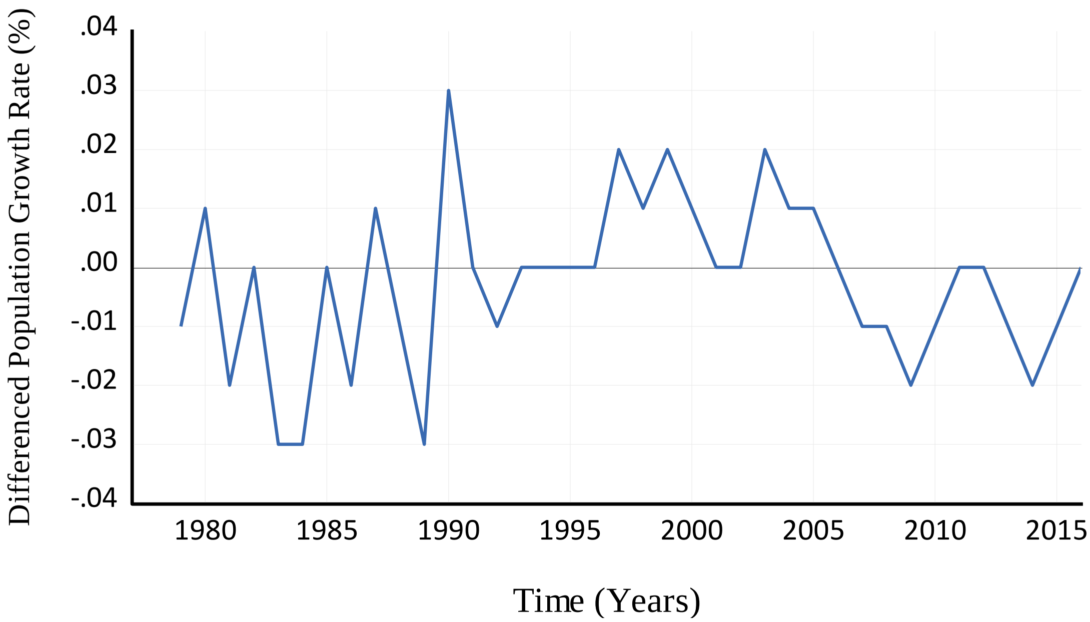


Figure 4.9: Second Differences of Population Growth Rate

Correlogram test gave the same indication that the second differences of this variable were stationary as earlier shown. The correlogram of the variable is presented in table 4.5 below.

Table 4.5: Correlogram of Second Differences of Population Growth Rate

Sample: 1977 2016
Included observations: 38

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.167	0.167	1.1413	0.285
		2	0.192	0.169	2.7026	0.259
		3	0.272	0.230	5.9082	0.116
		4	-0.031	-0.137	5.9509	0.203
		5	0.284	0.252	9.6611	0.085
		6	0.055	-0.066	9.8024	0.133
		7	0.044	0.027	9.8967	0.195
		8	0.044	-0.120	9.9931	0.266
		9	-0.143	-0.096	11.066	0.271
		10	-0.097	-0.168	11.578	0.314
		11	-0.260	-0.220	15.387	0.165
		12	-0.116	0.008	16.171	0.184
		13	-0.067	0.039	16.444	0.226
		14	-0.231	-0.083	19.816	0.136
		15	-0.205	-0.161	22.597	0.093
		16	-0.259	-0.074	27.236	0.039

The unit root test showed absence of a unit root after applying the second differences. The null hypothesis was rejected after taking the second differences of the variable. The results are as presented in table 4.6 below.

Table 4.6: Unit Root Test for the Second Differences of Population Growth Rate

Null Hypothesis: D(POPGR,2) has a unit root			
Exogenous: Constant, Linear Trend			
Lag Length: 0 (Automatic - based on SIC, max . lag=9)			
		t-Statistic	**Prob.***
Augmented Dickey-Fuller test statistic		-4.965318	0.0015
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

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

4.4.4 Inflation Rate

This variable's first differences are stationary as seen in figure 4.10. It had no heteroscedasticity problem, and therefore there was no need for logarithmic transformation. The graph in figure 4.10 below presents the results.

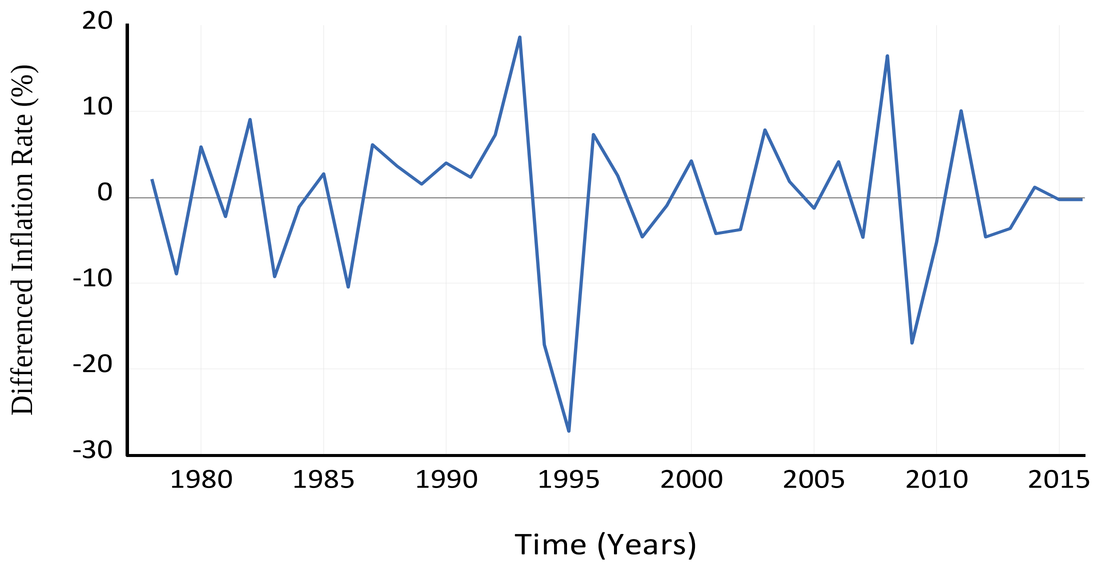


Figure 4.10: First Difference of Inflation Rate

Correlogram test was also carried out on this variable and the values of the autocorrelation confirmed that the first differences were stationary as observed in table 4.7

Table 4.7: Correlogram of First Difference of Inflation Rate

Sample: 1977 2016
Included observations: 39

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.182	-0.182	1.3998	0.237
		2	-0.311	-0.356	5.5803	0.061
		3	0.126	-0.019	6.2803	0.099
		4	-0.003	-0.103	6.2808	0.179
		5	-0.047	-0.036	6.3826	0.271
		6	-0.103	-0.180	6.8926	0.331
		7	-0.007	-0.111	6.8949	0.440
		8	0.021	-0.124	6.9180	0.546
		9	-0.071	-0.159	7.1888	0.617
		10	-0.074	-0.231	7.4925	0.678
		11	0.153	-0.036	8.8297	0.638
		12	0.091	-0.001	9.3254	0.675
		13	-0.241	-0.255	12.903	0.455
		14	-0.026	-0.256	12.947	0.531
		15	0.323	0.047	19.907	0.176
		16	-0.051	-0.062	20.084	0.216

The unit root test conducted on this variable showed stationarity after applying the first differences. The null hypothesis that it had a unit root was rejected. These results are as presented in table 4.12 below.

Table 4.8: Unit Root Test of the First Differences of Inflation Rate

Null Hypothesis: D(IR) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, max. lag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.494538	0.0000
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

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

4.4.5 Commercial Banks Weighted Interest Rate

This variable appeared to be homoscedastic and therefore, it was not logical to conduct logarithmic transformation on it. The first differences were stationary as presented on the graph in figure 4.11 below.

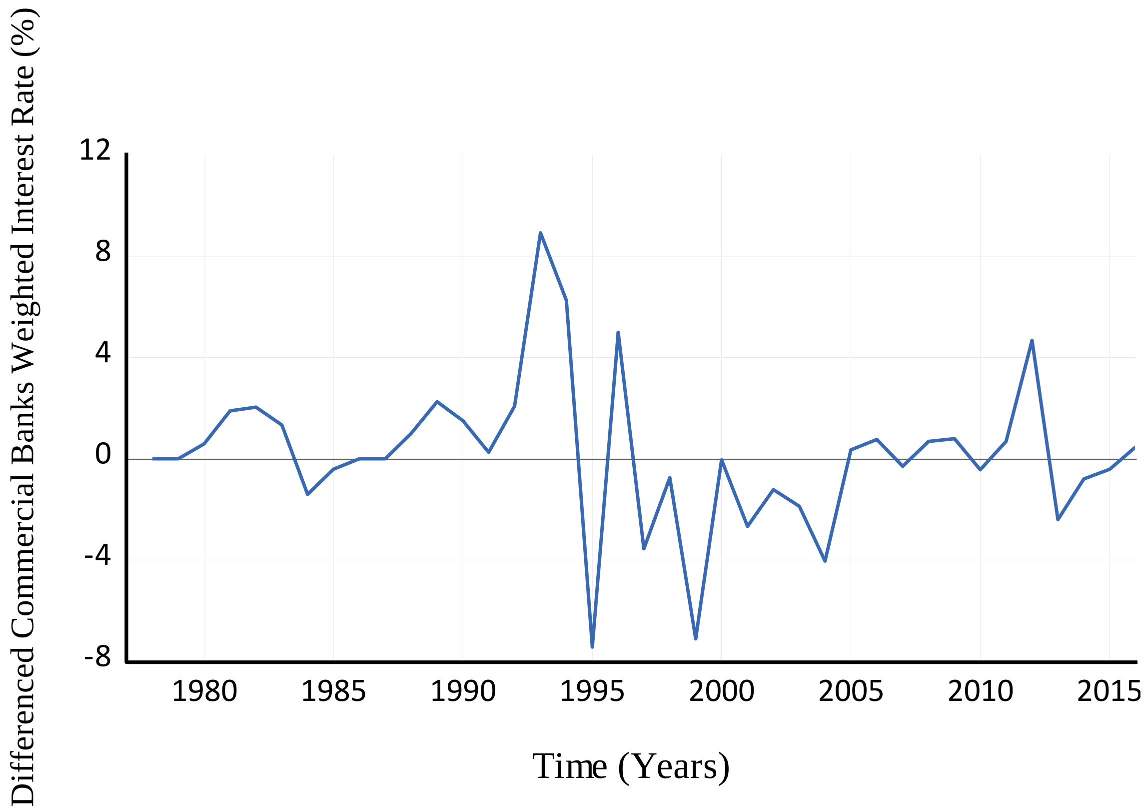


Figure 4.11: First Differences of Commercial Banks Weighted Interest Rate

Correlogram test on the variable indicated stationarity of the first differences. The results are as presented in table 4.9.

Table 4.9: Correlogram of the First Differences of Commercial Banks Weighted Interest Rate

Sample: 1977 2016
Included observations: 39

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.004	-0.004	0.0008	0.978
		2	0.148	0.148	0.9442	0.624
		3	0.046	0.049	1.0401	0.792
		4	0.215	0.198	3.1426	0.534
		5	-0.104	-0.119	3.6486	0.601
		6	-0.120	-0.194	4.3494	0.629
		7	-0.066	-0.069	4.5649	0.713
		8	-0.187	-0.199	6.3715	0.606
		9	-0.078	-0.007	6.6962	0.669
		10	-0.156	-0.050	8.0369	0.625
		11	-0.068	-0.046	8.3019	0.686
		12	0.033	0.137	8.3657	0.756
		13	-0.061	-0.076	8.5965	0.803
		14	-0.017	-0.054	8.6148	0.855
		15	0.009	-0.019	8.6206	0.897
		16	0.061	-0.061	8.8795	0.918

Unit root test for this variable showed stationarity of the first differences. Therefore, the null hypothesis that the commercial banks weighted interest rate had a unit root was rejected. Table 4.10 presents these results.

Table 4.10: Unit Root Test for the First Differences of Commercial Banks Weighted Interest Rate

Null Hypothesis: D(CBWR) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, max. lag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.078760	0.0001
Test critical values:	1% level	-4.219126	
	5% level	-3.533083	
	10% level	-3.198312	

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

4.4.6 US Dollar to Kenya Shillings Exchange Rate

The first differences of this variable were found to be stationary. Differencing of the variable's time series data gave a graph shown in figure 4.12 below.

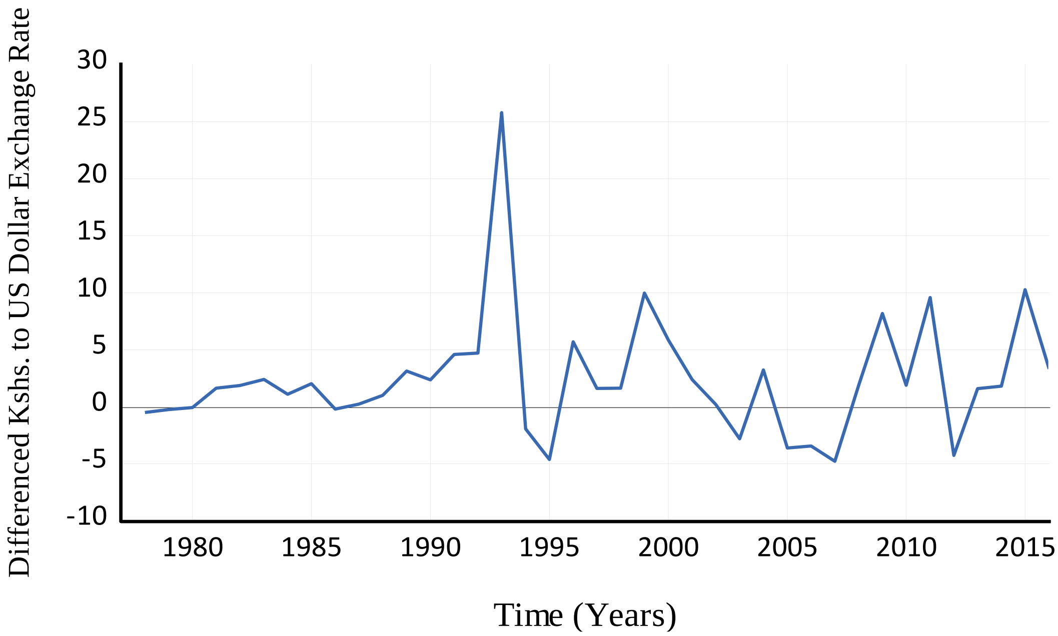


Figure 4.12: First Differences of Exchange Rate

The data was also subjected to correlogram test which indicated that the first differences were stationary. This was indicated by autocorrelation and AC values as can be observed in table 4.11 presented overleaf.

Table 4.11: Correlogram of the First Differences of Exchange Rate

Sample: 1977 2016
Included observations: 39

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.039	0.039	0.0637	0.801
		2	-0.060	-0.062	0.2190	0.896
		3	-0.034	-0.029	0.2699	0.966
		4	-0.061	-0.062	0.4377	0.979
		5	-0.079	-0.078	0.7276	0.981
		6	0.058	0.056	0.8926	0.989
		7	0.043	0.026	0.9858	0.995
		8	-0.035	-0.040	1.0505	0.998
		9	-0.057	-0.057	1.2238	0.999
		10	-0.079	-0.079	1.5716	0.999
		11	0.047	0.058	1.6964	0.999
		12	-0.126	-0.149	2.6369	0.998
		13	-0.243	-0.262	6.2665	0.936
		14	-0.284	-0.344	11.443	0.651
		15	-0.046	-0.140	11.585	0.710
		16	0.131	0.058	12.778	0.689

A unit root test carried out on the data indicated stationarity after differencing once. The null hypothesis that the variable had a unit root was rejected. Table 4.12 below presents these results.

Table 4.12: Unit Root Test of the First Differences of Exchange Rate

Null Hypothesis: D(ER) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, max. lag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.720108	0.0002
Test critical values:	1% level	-4.219126	
	5% level	-3.533083	
	10% level	-3.198312	

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

4.4.7 Stationarity Test Observations

In this research, stationarity test process was taken as a serious and crucial process. The key factor for this being that, the reliability and accuracy of the results of the research are very much dependent on the stationarity of the time series data. This is because unstationarity of the time series data may lead to spurious regression (Gujarati & Porter, 2009). In order to avoid this situation, the time series data for all the economic variables were thoroughly investigated for this condition. Three different types of tests were carried out on the time series data and observations for each test discussed hereafter.

Detrending and differencing was the first check for stationarity of all the economic variables. It was realized that all the time series data for all the variables were achieving stationarity after taking their first differences except one. This was population growth rate which achieved stationarity after taking its second differences. A graph with no trend is an indication of stationarity for a specific variable. The results of all these variables are given in figures 4.7, 4.8, 4.9, 4.10, 4.11 and 4.12.

The second test which was carried out on the time series data was the Autocorrelation Functions (ACF) and the correlogram test. Each variable was subjected to this test and results displayed on tables. It was noticed that apart from one variable; population growth rate, which had its second differences stationary, the rest of the variables had their first differences stationary. As observed from all the tables of each result, the values under the AC column were tending to zero which was an indication of stationarity. All these results are presented in tables 4.1, 4.3, 4.5, 4.7, 4.9 and 4.11.

Finally, the Augmented Dickey-Fuller (ADF) unit root test was conducted. It is said to be a powerful tool for dealing with the presence a unit root in a time series data. The null hypothesis was that a specific variable’s first/second differences had a unit root. This null hypothesis was rejected in all the variables which were a confirmation of stationarity. It was further confirmed by their P-values which were zero in all the cases.

The unit root test results are presented in tables 4.2, 4.4, 4.6, 4.8, 4.10 and 4.12. It was therefore concluded that:

1) The first and second differences of the time series data were stationary
2) The time series data in this research are integrated of order (1) and (2)
3) Further analysis could be conducted.

Based on the foregoing conclusions, correlation analysis is now presented.

4.5 Correlation Analysis

Correlation analysis was done to establish the nature of correlation that existed between macro- economic factors and construction output in Kenya. The dependent variable; construction output was correlated to establish the nature of relationship between them and the following macro-economic factors:

1) Population growth rate
2) Unemployment rate
3) Exchange rate
4) Commercial banks weighed interest rate and
5) Inflation rate

The above listed macro-economic factors are the independent variables in this research thesis.

Table 4.13: Correlation coefficients (r)

	DLOG(CO)
DLOG(CO)	1.000000
D(CBWR)	0.079586
D(ER)	-0.082287
D(IR)	-0.063929
D(POPGR,2)	0.155604
D(UNEMPR)	0.265496

The nature of the relationships that exist between the five (5) macro-economic factors and construction output are now established and further explained as follows:

4.5.1 Correlation of Construction Output and Macro- Economic Factors

Construction output has been the main focus of this research from the onset. The study focused on establishing whether macro – economic factors have any influence on Kenya's construction output levels. As observed from table 4.13, the first differences of the logarithm of construction output are directly correlated to four (3) variables of macro-economic factors. They include the first differences of unemployment rate, commercial banks weighted interest rate and the second differences of population growth rate. Their correlation coefficients (r) are 0.27, 0.08 and 0.16 respectively.

The dependent variable is as well inversely correlated with two (2) stationary macro-economic variables. They include the first differences of inflation rate and US dollar to Kenya shilling exchange rate. Their correlation coefficients (r) are -0.06 and -0.08 respectively.

It is however noted from the observations made from table 4.13 that one (1) stationary variable deviates from a *priori*. This means that it presents unexpected results. The nature of relationship observed between the explanatory variable and the dependent variable is the opposite of what should normally happen. Otherwise, it should be vice versa.

4.5.2 Multicollinearity

Multicollinearity is one of the concerns which should be addressed in the process of time series analysis. It is a situation that happens in time series analysis where the explanatory variables are themselves related (Gujarati & Porter, 2009). In multiple regressions, it is a term used in reference to correlation amongst the explanatory variables (Goldberger, 1991). As observed in Goldberger, (1991) and Gujarati, (2009), multicollinearity, just like micro numerosity arises when the number of observations barely exceeds the number of parameters to be estimated in a model. This is not the case in this research and therefore, micro numerosity and multicollinearity do not pose any major concern. Furthermore, in view of the practical consequences as highlighted in Goldberger, (1991) and Gujarati, (2009), and comparing with the parameters of the model being estimated, there seems to be no problem of multicollinearity in the modeling of construction output in this research. However, as a way of confirming this position, multicollinearity test is performed and results are shown in table 4.14.

Table 4.14: Correlation coefficients (r) Amongst Differenced Explanatory Variables

	D(CBWR)	D(IR)	D(ER)	D(UNEMPR)	D(POPGR,2)
D(CBWR)	1.000000	0.316237	0.304287	0.069060	-0.224846
D(IR)	0.316237	1.000000	0.428723	-0.101277	0.240779
D(ER)	0.304287	0.428723	1.000000	0.151139	-0.046999
D(UNEMPR)	0.069060	-0.101277	0.151139	1.000000	0.011793
D(POPGR,2)	-0.224846	0.240779	0.046999	0.011793	1.000000

The correlation coefficients (r) as observed from table 4.14 are very low with the highest coefficient being recorded between inflation rate and exchange rate. The coefficient is r = 0.4 which is in the lower range. Based on these observations, it can be concluded that, there is no multicollinearity problem amongst these explanatory variables and therefore further analysis can be carried out.

4.6 Multiple Regression Analysis

The main purpose of carrying out the regression analysis of the time series data was to find out if there existed any influence of macro-economic factors on Kenya's construction output. While focusing on this goal, the study had purposed to test the null hypothesis that $\beta = 0$ for every β_i in the regression model. This has a meaning that construction output in Kenya is not influenced by any of the explanatory variables included in the regression model.

This section presents results emanating from Eviews software output which generated a multiple regression of construction output which was regressed on the macro-economic factors in Kenya. This multiple regression analysis process involved the regression of construction output (CO) variable on the other Macro-economic variables. For this reason, differenced natural logarithm of construction output (DLOGCO) was regressed on the first differences of unemployment rate (DUNEMPR), Commercial Banks weighted interest rate (DCBWR), US dollar to Kenya Shilling exchange rate (DER), inflation rate (DIR) and the second differences of population growth rate (DPOPGR,2) in Kenya. As earlier discussed, the differencing of all the time series data used in this research was for purposes of ensuring stationarity in order to guarantee reliability of the results obtained. The study had purposed to collect and analyze data for all these variables from 1963 to 2019 but this became impossible due to lack of accurate records. Therefore, data from 1977 to 2019 was collected and analyzed. This data was found to be adequate enough to produce reliable results. For purposes of this regression analysis, formal construction output - quantified and released to the public by KNBS from 1977 to 2019 was used. The same period applies to the data which were collected and analyzed for explanatory variables. The regression coefficients were tested at $\alpha = 0.05$ level of significance. The effect variable and the five predictors were all non-stationary and hence the need to transform them through differencing. This can be observed in this chapter in section 4.3. The predictand variable was construction output (CO). The predictors/regressors were population growth rate (POP), unemployment rate (UEMPR), commercial banks weighted interest rate (CBWR), Kenya shilling to US dollar exchange rate (ER) and inflation rate (IR) in Kenya.

The following model was used for regression analysis in this research:

$$\mathbf{CO_t = \alpha + \beta_1 CBWR_t + \beta_2 IR_t + \beta_3 ER_t + \beta_4 UEMPR_t + \beta_5 POPGR_t + \varepsilon_t} \ldots\ldots\ldots\ldots \quad \mathbf{(11)}$$

Where:

CO_t	=	Construction Output in a specific year
$UNEMPR_t$	=	Unemployment rate at any specific year
$CBWR_t$	=	Commercial Bank' Weighted Interest Rates in a specific year
$POPGR_t$	=	Population growth rate at a specific year
IR_t	=	Inflation Rates in a specific year
ER_t	=	Kenya shilling per US dollar Exchange Rate in a specific year
β	=	Regression Coefficient
ε	=	Error Term or Residual

α **=** Intercept (this is the value of CO_t when predictor/regressor variables are set at zero)

The null hypothesis was H_0: $\beta_i = 0$

The research hypothesis was H_1: $\beta_i \neq 0$ for at least one coefficient β

The full results which were arrived at after regression analysis processes are displayed in tables 4.15 and 4.21 respectively.

Table 4.15: Multiple Regression Results for Dlog(CO)

Dependent Variable: DLOG(CO)				
Method: Least Squares				
Date: 07/12/20 Time: 11:08				
Sample (adjusted): 1979 2016				
Included observations: 38 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.224531	0.093114	2.411346	0.0218
D(CBWR)	0.029735	0.030388	0.978526	0.3352
D(IR)	-0.005176	0.011599	-0.446293	0.6584
D(ER)	-0.012364	0.017559	-0.704159	0.4864
D(UNEMPR)	0.447367	0.301428	1.484162	0.1476
D(POPGR,2)	6.734537	6.373976	1.056568	0.2986
R-squared	0.129294	Mean dependent var		0.214547
Adjusted R-squared	-0.006754	S.D. dependent var		0.497171
S.E. of regression	0.498847	Akaike info criterion		1.590906
Sum squared resid	7.963159	Schwarz criterion		1.849472
Log likelihood	-24.22722	Hannan-Quinn criter.		1.682902
F-statistic	0.950353	Durbin-Watson stat		2.354030
Prob(F-statistic)	0.462409			

With reference to table 4.15, regression coefficients for every explanatory variable are now obtained from the regression output table. The coefficients as they appear in the table are as follows:

- 0.03 for the first differences of commercial banks weighted interest rate (CBWR)
- -0.01 for the first differences of inflation rate (IR)
- -0.01for the first differences of Kshs. To US dollar exchange rate (ER)
- 0.45 for the first differences of unemployment rate (UNEMPR)
- 6.73 for the second differences of population growth rate (POPGR)

Observations from the same table, that is table 4.15, show that some coefficients of some time series variables are actually negative. The variables are namely inflation rate and exchange rate. The negative signs prefixed before these two (2) variables are an indication of the inverse relationship between the explanatory variables and construction output in Kenya

The remaining other three (3) variables have positive coefficients which is also an inconsistency with a priori. This inconsistency should be noted as well since from a priori point of view, it should be vice versa. These variables displaying this anomaly are commercial banks weighted interest rates, population growth rate and unemployment rate.

Based on the results given in table 4.15, the following equation describes construction output in Kenya: -

$$\mathbf{dlogCO_t = 0.22 + 0.03 \times dCBWR_t - 0.01 \times dIR_t - 0.01 \times dER_t + 0.45 \times dUNEMPR_t + 6.73 \times 2dPOPGR_t} \quad \textbf{(12)}$$

Where:

$dLogCO_t = LogCO_t - LogCO_{t-1}$ (the first difference of logarithm of construction output)

$dCBWR_t = CBWR_t - CBWR_{t-1}$ (the first difference of commercial banks interest rate)

$dIR_t = IR_t - IR_{t-1}$ (the first difference of inflation rate)

$dER_t = ER_t - ER_{t-1}$ (the first difference of exchange rate)

$dUNEMPR_t = UNEMPR_t - UNEMPR_{t-1}$ (the first difference of unemployment rate)

$2dPOPGR_t$= $POPGR_t$ - $POPGR_{t-1}$ – $POPGR_{t-2}$ = (the second difference of population growth rate)

The regression equation above when it is expressed in terms of variable levels is shown hereafter: -

$LogCO_t$ - $LogCO_{t-1}$ = 0.22 + 0.03 X ($CBWR_t$ - $CBWR_{t-1}$) – 0.01 X (IR_t - IR_{t-1}) – 0.01 X (ER_t - ER_{t-1}) +0.45 X ($UNEMPR_t$ – $UNEMPR_{t-1}$) + 6.73 X ($POPGR_t$ - $POPGR_{t-1}$ – $POPGR_{t-2}$)

Collecting the like terms and working out the brackets makes the said equation change to the following

$LogCO_t$ = 0.22 + $LogCO_{t-1}$+ 0.03$CBWR_t$ - 0.03$CBWR_{t-1}$ – 0.01IR_t + 0.01IR_{t-1} – 0.01ER_t + 0.01ER_{t-1} + 0.45$UNEMPR_t$ + 0.45$UNEMPR_{t-1}$ + 6.73$POPGR_t$ - 6.73$POPGR_{t-1}$ – 6.73$POPGR_{t2}$………………………………………………………………… (13)

The equation above has an implication that Kenya's construction output levels in a specific year has dependency on (i) construction output levels in the previous year (ii) commercial banks weighted interest rate in the current and the previous year (iii) inflation rate in the current and the previous year (iv) Kenya shillings to the US dollar exchange rate in the current and the previous year (v) unemployment rate in the current and the previous year and finally, (vii) population growth rate in the current and the previous two years.

Positive regression coefficients are observed for $CBWR_t$, IR_{t-1}, ER_{t-1}, $UNEMPR_t$, $UNEMPR_{t-1}$ and $POPGR_t$. The implication here is that $POPGR_t$, $CBWR_t$ and $UNEMPR_t$ support output levels of construction in the country in the current year, while IR_{t-1}, ER_{t-1}, $UNEMPR_{t-1}$, $POPGR_{t-1}$ and $POPGR_{t-2}$ appear to increase construction output levels in the previous year. These findings are going contrary to the basic economic theory and a priori.

It is also observed that regression coefficients for $CBWR_{t-1}$, IR_t, ER_t $POPGR_{t-1}$ and $POPGR_{t-2}$ are negative. This has a meaning that IR_t and ER_t have an effect of reducing the construction output levels in the current year except $CBWR_{t-1}$ $POPGR_{t-1}$ and $POPGR_{t-2}$ which have similar effects but in the previous year and previous two years respectively. This is in line with the basic economic theory and a priori.

With regard to the observations made so far, it has been seen that some variables have displayed different behaviours from the basic economic theory and a priori. These anomalies are attributable to the weak link between them and construction output levels in Kenya as indicated by their regression coefficients. This is further reinforced by the observed R^2 value of the model developed which has low explanatory powers. This R^2 value of the developed model is 0.13.

4.7 Regression of construction Output on Lagged Regressors

Considering the low R^2 value which was obtained in the previous section, it was decided to carry out another regression analysis of construction output level on lagged values of all explanatory variables in this research. The key reason for arriving at this decision was to find out if a higher value of R^2 could be obtained.

The researcher relooked at the regression results obtained earlier in table 4.15 and realized the possibility of construction output levels being highly influenced by lagged values of the explanatory variables. This necessitated the need to carry out another regression of construction output on lagged regressors. The initial stages of this process were firstly, to carry out a correlation analysis of lagged explanatory variables to facilitate the selection of the lags to be included in the regression analysis for purposes of ensuring their consistency with the basic economic theory and a priori.

4.7.1 Correlation Analysis of Construction Output and Lagged Regressors

For purposes of selecting and eventual inclusion of the necessary lags of explanatory variable in the regression analysis, correlation analysis for lagged explanatory variables was carried out. This also made it possible for the researcher to include only those lags which were consistent with the basic economic theory and a priori into the regression analysis.

Therefore, correlation analysis was carried out for construction output in Kenya and lagged explanatory variables and the highest lags selected according to their consistency with the basic economic theory and a priori. The coefficients of correlation for the lagged regressors were presented in tables beginning with table 4.16 through table 4.20 in this section. Lags of the variables up to twelve (12) years were used.

(a) Correlation of First Differences of Log Construction Output and Lagged First Differences of Commercial Banks Weighted Interest rate

Lag seven (7) carries the highest correlation coefficient that was picked for inclusion in the lagged variables' regression model. Correlation output table 4.16 displays these results. This chosen value is consistent with a priori and basic economic theory. This correlation coefficient which was picked is as shown in the above-mentioned table is -0.37.

Table 4.16: Correlation coefficients of First Differences of Log Construction Output (DLogCO) and Lagged First Differences of Commercial Banks Weighted Interest rate (CBWR)

	DLOG(CO)
DLOG(CO)	1.000000
D(CBWR)	0.113235
D(CBWR(-1))	-0.265280
D(CBWR(-2))	0.208904
D(CBWR(-3))	-0.332996
D(CBWR(-4))	0.151814
D(CBWR(-5))	0.020201
D(CBWR(-6))	0.308605
D(CBWR(-7))	**-0.365096**
D(CBWR(-8))	0.313857
D(CBWR(-9))	0.424017
D(CBWR(-10))	0.138733
D(CBWR(-11))	-0.084535
D(CBWR(-12))	0.179374

(b) Correlation of First Differences of Log Construction Output and Lagged First Differences of Inflation rate

This variable's correlation coefficient with first differences of logarithm of construction output was picked at lag seven (7). At this lag, the correlation coefficient was in accordance with the basic economic theory and a priori. The correlation coefficient is -0.43 as observed from table 4.17.

Table 4.17: Correlation coefficients of the First Differences of Log Construction Output and Lagged First Differences of Inflation rate

	DLOG(CO)
DLOG(CO)	1.000000
D(IR)	-0.086696
D(IR(-1))	-0.099030
D(IR(-2))	0.060784
D(IR(-3))	-0.272743
D(IR(-4))	-0.094117
D(IR(-5))	0.219557
D(IR(-6))	0.258069
D(IR(-7))	**-0.430998**
D(IR(-8))	-0.239953
D(IR(-9))	0.373164
D(IR(-10))	0.037026
D(IR(-11))	0.013670
D(IR(-12))	0.159969

(c) Correlation of First Differences of Log Construction Output and Lagged First Differences of US dollar to Kenya Shillings Exchange rate

The correlation coefficient which was included in the regression model was picked from lag seven (7). At this lag was the highest coefficient of -0.26 which was found to be consistent with a priory and basic economic theory. Table 4.18 present these results.

Table 4.18: Correlation Coefficients of First Differences of Log Construction Output and Lagged First Differences of US dollar to Kenya Shillings Exchange rate

	DLOG(CO)
DLOG(CO)	1.000000
D(ER)	-0.094871
D(ER(-1))	0.030621
D(ER(-2))	0.117952
D(ER(-3))	0.302160
D(ER(-4))	-0.046581
D(ER(-5))	0.270001
D(ER(-6))	0.057548
D(ER(-7))	**-0.260721**
D(ER(-8))	-0.227903
D(ER(-9))	0.566399
D(ER(-10))	0.009647
D(ER(-11))	0.050477
D(ER(-12))	0.098094

(d) Correlation of First Differences of Log Construction Output and Lagged First Differences of Unemployment rate

Unemployment rate (UNEMPR) correlation coefficient with the first difference of the logarithm of construction output (DLogCO) levels in Kenya was picked at lag eleven (11). At this lag length, the coefficient is the highest and it is consistent with the basic economic theory and a priori. This coefficient value is -0.59 and these results are displayed in table 4.19.

Table 4.19: Correlation Coefficients of First Differences of Log Construction Output and Lagged First Differences of Unemployment rate

	DLOG(CO)
DLOG(CO)	1.000000
D(UNEMPR)	0.244528
D(UNEMPR(-1))	0.033043
D(UNEMPR(-2))	0.104877
D(UNEMPR(-3))	0.145098
D(UNEMPR(-4))	-0.014014
D(UNEMPR(-5))	-0.209288
D(UNEMPR(-6))	0.032256
D(UNEMPR(-7))	-0.358739
D(UNEMPR(-8))	0.033334
D(UNEMPR(-9))	0.044140
D(UNEMPR(-10))	0.156329
D(UNEMPR(-11))	**-0.588206**
D(UNEMPR(-12))	0.219996

(e) Correlation of First Differences of Log Construction Output and Lagged First Differences of Population Growth rate

Population growth rate and construction output had their highest inverse correlation coefficient at lag ten (10). This is the coefficient which was included in the regression model of lagged values. The value of this coefficient is -0.24 and this is quite in line with the economic theory and a priori. The results are as presented in table 4.20.

Table 4.20: Correlation Coefficients of First Differences of Log Construction Output and Lagged First Differences of Population Growth rate

	DLOG(CO)
DLOG(CO)	1.000000
D(POPGR,2)	0.021368
D(POPGR(-1),2)	0.075922
D(POPGR(-2),2)	0.061355
D(POPGR(-3),2)	0.105208
D(POPGR(-4),2)	-0.015169
D(POPGR(-5),2)	0.231025
D(POPGR(-6),2)	0.019673
D(POPGR(-7),2)	-0.052354
D(POPGR(-8),2)	0.143109
D(POPGR(-9),2)	-0.074129
D(POPGR(-10),2)	**-0.239874**
D(POPGR(-11),2)	0.031622
D(POPGR(-12),2)	0.179384

4.7.2 Regression Model for Construction Output and Lagged macro-economic Factors

In this sub-section, results are presented as obtained during multiple regression of construction output and lagged values of macro-economic factors. This multiple regression process involved the logarithm of differenced construction output levels as the dependent variable and the following lagged macro-economic factors in Kenya as independent variables:

- Commercial Banks' Weighted Interest Rate (CBWR)
- Unemployment Rate (UNEMPR)
- Inflation Rate (IR)
- Population Growth Rate (POPGR)
- US Dollar to Kenya Shilling Exchange Rate (ER)

The regression coefficients were tested at α = 0.05 level of significance. Stationarity transformation was first carried out on all the regressors before running the regression. This is because all the variables were initially unstationary. Their first differences were found to be stationary after transformation except one, whose second differences were stationary. This was population growth rate whose second differences were found to be stationary. Once the regression analysis was performed, the results were presented in table 4.21 shown below.

Table 4.21: Regression Results of First Differences of Construction Output on Lagged Regressors

Dependent Variable: DLOG(CO)
Method: Least Squares
Date: 07/12/20 Time: 17:11
Sample (adjusted): 1989 2016
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.385721	0.103895	3.712602	0.0012
D(CBWR(-7))	-0.010038	0.030201	-0.332368	0.7428
D(IR(-7))	-0.009237	0.010711	-0.862324	0.3978
D(ER(-7))	-0.021731	0.019066	-1.139752	0.2666
D(UNEMPR(-11))	-1.230023	0.421544	-2.917896	0.0080
D(POPGR(-10),2)	-1.100751	6.150287	-0.178976	0.8596

R-squared	0.480696	Mean dependent var	0.269791
Adjusted R-squared	0.362672	S.D. dependent var	0.568640
S.E. of regression	0.453961	Akaike info criterion	1.445800
Sum squared resid	4.533781	Schwarz criterion	1.731273
Log likelihood	-14.24120	Hannan-Quinn criter.	1.533072
F-statistic	4.072873	Durbin-Watson stat	1.681191
Prob(F-statistic)	0.009075		

Table 4.21 presents the coefficients of regression of the differenced logarithm of construction output levels and differenced and lagged macro-economic factors. These regression coefficients as obtained from the table are:

- -0.01 for Commercial Banks' Weighted Interest Rate (CBWR)
- -1.23 for Unemployment Rate (UNEMPR)
- -0.01 for Inflation Rate (IR)
- -1.1 for Population Growth Rate (POPGR)
- -0.02 for US Dollar to Kenya Shilling Exchange Rate (ER)

It is now observed from the integers listed above that all coefficients are negative. This is an implication that all the lagged explanatory variables tend to decrease construction output in the country. It is therefore seen that all these explanatory variables present results which are consistence with the basic economic theory and a priori. They hence include unemployment rate (UNEMPR), commercial banks' weighted interest rate (CBWR), Inflation rate (IR), US dollar to Kenya shilling exchange rate (ER) and population growth rate (POPGR). They all exhibit a clear consistency with a priori and they agree with the basic economic theory. Therefore, on the basis of these results as earlier displayed in table 4.20, the following equation is now formed: -

$$\mathbf{dlogCO_t = 0.39 - 0.01 \times dCBWR_{t-7} - 1.23 \times dUNEMPR_{t-11} - 0.01 \times dIR_{t-7} - 1.1 \times 2dPOPGR_{t-10} - 0.02 \times dER_{t-7}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \mathbf{(14)}$$

Where:-

$dlogCO_t = logCO_t - logCO_{t-1}$ (for first difference of logarithm of construction output (CO)

$dCBWR_{t-7} = CBWR_{t-7} - CBWR_{t-8}$ (for the first differences of Commercial Banks' Weighted Interest Rate (CBWR)

$dUNEMPR_{t-11} = UNEMPR_{t-11} - UNEMPR_{t-12}$ (for the first differences of Unemployment Rate (UNEMPR)

$dIR_{t-7} = IR_{t-7} – IR_{t-8}$ (for the first differences of Inflation Rate (IR)

$2dPOPGR_{t-10} = POPGR_{t-10} – POPGR_{t-11} - POPGR_{t-12}$ (for the second differences of Population Growth Rate (POPGR)

dERt-7 = $ER_{t-7} – ER_{t-8}$ (for the first differences of the US Dollar to Kenya Shilling Exchange Rate (ER)

When the equation is expressed in terms of levels of variables, it appears as given below: -

$$\log CO_t – \log CO_{t-1} = 0.39 – 0.01 \times (CBWR_{t-7} – CBWR_{t-8}) – 1.23 \times (UNEMPR_{t-11} – UNEMPR_{t-12}) - 0.01 \times (IR_{t-7} – IR_{t-8}) - 1.1 \times (POPGR_{t-10} – POPGR_{t-11} - POPGR_{t-12}) - 0.02 \times (ER_{t-7} – ER_{t-8})$$

The like terms are eventually put together and the equation organized as follows: -

$$LogCO_t = 0.39 + LogCO_{t-1} – 0.01CBWR_{t-7} + 0.01CBWR_{t-8} – 1.23UNEMPR_{t-11} + 1.23UNEMPR_{t-12} - 0.01IR_{t-7} + 0.01IR_{t-8} - 1.1POPGR_{t-10} + 1.1POPGR_{t-11} + 1.1 POPGR_{t-12} - 0.02ER_{t-7} + 0.02ER_{t-8}$$

Finally, a model which describes Kenya's construction industry in relation to the macro-economic factors is now developed as below: -

$$\mathbf{LogCO_t = 0.39 + LogCO_{t-1} – 1.23UNEMPR_{t-11} + 1.23UNEMPR_{t-12} - 0.01IR_{t-7} + 0.01IR_{t-8} –1.1POPGR_{t-10} + 1.1POPGR_{t-11} + 1.1POPGR_{t-12} - 0.02ER_{t-7} + 0.02ER_{t-8} - 0.01CBWR_{t-7} + 0.01CBWR_{t-8}} \quad \textbf{(15)}$$

The equation developed above carries a meaning that construction output level in a specific year depends upon (i) construction output levels in the previous year, (ii) unemployment rate in the previous eleven (11) and twelve (12) years, (iii) inflation rate in the previous seven (7) and eight (8) years (iv) population growth rate in the previous ten (10) and Eleven (11) years and (v) US Dollar to Kenya Shillings exchange rate in the previous seven (7) and eight (8) years and (vi) Commercial banks weighted interest rates in the previous seven (7) and eight (8) years. The model is consistent with a priori and the basic economic theory. It therefore gives a clear picture of the actual economic behavior of the industry in Kenya based on the five (5) macro-economic factors.

4.8 Non-Linear Relationships between Construction Output and Macro-Economic Factors

Even though the results emanating from linear relationship between construction output and macro-economic factors in Kenya appear impressive, the researcher herein thought it wise to explore other non-linear relationships between the construction output and the macro-economic factors in question. The non-linear methods which were explored included quadratic and exponential relationships. The main idea behind this exploration was to compare and establish whether these relationships could produce better results than those realized through linear regression. The functions used for these explorations were all linear - in - parameters but nonlinear-in-variables.

4.8.1 Quadratic Regression of Construction output on Macro-Economic Factors

Generally, a quadratic function or model takes the form:

$$\mathbf{Y_t = \beta_1 + \beta_2 X_t + \beta_3 X_t^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \mathbf{(16)}$$

Where,

$\mathbf{Y_t}$ = Dependent Variable at a given year

X = Independent variables

$\boldsymbol{\beta}$ = Regression coefficients

t = A given time period

For the purpose of this research, five (5) quadratic regression models are formulated due to the presence of five (5) explanatory variables. Regression of each quadratic function of a variable on construction output is carried out and their regression parameters and R^2 values observed. The observed regression parameters and R^2 value indicates whether or not there is a quadratic relationship between construction output and the macro-economic factor in Kenya.

4.8.1.1 Quadratic Regression of Commercial Banks Weighted Interest Rate (CBWR) on Construction Output (CO)

The first differences of Commercial Banks Weighted Interest Rates were regressed on the first differences of Kenya's annual Construction Output using the following quadratic regression equation:

$$\mathbf{CO_t = \alpha + \beta_1(CBWR_t) + \beta_2(CBWR_t)^2 + \varepsilon_t \text{ ………………………………………. } (17)}$$

The results obtained after the quadratic regression are given in table 4.22.

Table 4.22: Quadratic Regression Results of differenced CBWR on Differenced CO

Dependent Variable: DLOG(CO)				
Method: Least Squares				
Sample (adjusted): 1978 2016				
Included observations: 39 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.204404	0.090154	2.267275	0.0295
D(CBWR)	0.012571	0.027212	0.461973	0.6469
D(CBWR)^2	0.000611	0.004600	0.132740	0.8951

R-squared	0.006861	Mean dependent var	0.211950
Adjusted R-squared	-0.048314	S.D. dependent var	0.490854
S.E. of regression	0.502571	Akaike info criterion	1.535646
Sum squared resid	9.092812	Schwarz criterion	1.663612
Log likelihood	-26.94509	Hannan-Quinn criter.	1.581559
F-statistic	0.124348	Durbin-Watson stat	2.105530
Prob(F-statistic)	0.883450		

Quadratic regression results from table 4.22 indicate an R^2 value of 0.006861. This R^2 value is very low meaning that quadratic model has no explanatory powers. The coefficients as observed are insignificant and therefore, there is no quadratic relationship between the commercial banks weighted interest rate and construction output in Kenya for the period in question.

4.8.1.2 Quadratic Regression of Inflation Rate (IR) on Construction Output (CO)

The first differences of IR were regressed on the first differences of Kenya's annual CO using the following quadratic regression equation:

$$\mathbf{CO_t} = \alpha + \boldsymbol{\beta_1}(\mathbf{IR_t}) + \boldsymbol{\beta_2}(\mathbf{IR_t})^2 + \boldsymbol{\varepsilon_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(18)}$$

The quadratic regression results of the above model are displayed in table 4.23.

Table 4.23: Quadratic Regression Results of differenced IR on Differenced CO

Dependent Variable: DLOG(CO)
Method: Least Squares
Sample (adjusted): 1978 2016
Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.232181	0.092247	2.516941	0.0164
D(IR)	-0.005500	0.010131	-0.542924	0.5905
D(IR)^2	-0.000289	0.000623	-0.464476	0.6451

R-squared	0.010194	Mean dependent var	0.211950
Adjusted R-squared	-0.044796	S.D. dependent var	0.490854
S.E. of regression	0.501728	Akaike info criterion	1.532284
Sum squared resid	9.062298	Schwarz criterion	1.660251
Log likelihood	-26.87954	Hannan-Quinn criter.	1.578198
F-statistic	0.185375	Durbin-Watson stat	2.195861
Prob(F-statistic)	0.831581		

This model has no explanatory powers as observed from table 4.23 above. The R^2 value is so low and it confirms this scenario as regards to the model. The coefficients are insignificant implying that there is no quadratic relationship between inflation rate and construction output in Kenya.

4.8.1.3 Quadratic Regression of Exchange Rate (ER) on Construction Output (CO)

The first differences of ER were regressed on the first differences of Kenya's annual CO using the following quadratic regression equation:

$$CO_t = \alpha + \beta_1(ER_t) + \beta_2(ER_t)^2 + \varepsilon_t \quad \ldots\ldots\ldots\ldots \quad (19)$$

The quadratic regression results of the above model are as displayed in table 4.24.

Table 4.24: Quadratic Regression Results of differenced ER on Differenced CO

Dependent Variable: DLOG(CO)
Method: Least Squares
Sample (adjusted): 1978 2016
Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.230273	0.088590	2.599308	0.0135
D(ER)	-0.010389	0.026405	-0.393439	0.6963
D(ER)^2	0.000193	0.001321	0.146310	0.8845

R-squared	0.006830	Mean dependent var	0.211950
Adjusted R-squared	-0.048346	S.D. dependent var	0.490854
S.E. of regression	0.502579	Akaike info criterion	1.535677
Sum squared resid	9.093093	Schwarz criterion	1.663643
Log likelihood	-26.94570	Hannan-Quinn criter.	1.581590
F-statistic	0.123788	Durbin-Watson stat	2.185338
Prob(F-statistic)	0.883942		

As observed from table 4.23, the value of R^2 is quite low. This implies that the explanatory powers of this model are almost zero. The observed coefficients are also not significant. This means that there is no quadratic relationship between USD to Kshs. Exchange rate and construction output in Kenya with regard to the analyzed data.

4.8.1.4 Quadratic Regression of unemployment rate (UEMPR) on Construction Output (CO)

The first differences of Unemployment Rates were regressed on the first differences of Kenya's annual Construction Output using the following quadratic regression equation:

$$CO_t = \alpha + \beta_1(UEMPR_t) + \beta_2(UEMPR_t)^2 + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (20)$$

The quadratic regression results of the above model are as displayed in table 4.25.

Table 4.25: Quadratic Regression Results of differenced UEMPR on Differenced CO

Dependent Variable: DLOG(CO)
Method: Least Squares
Sample (adjusted): 1978 2016
Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.182295	0.083366	2.186672	0.0353
D(UNEMPR)	0.473121	0.300209	1.575969	0.1238
D(UNEMPR)^2	-0.021696	0.375129	-0.057835	0.9542

R-squared	0.071540	Mean dependent var	0.211950
Adjusted R-squared	0.019959	S.D. dependent var	0.490854
S.E. of regression	0.485931	Akaike info criterion	1.468303
Sum squared resid	8.500636	Schwarz criterion	1.596269
Log likelihood	-25.63190	Hannan-Quinn criter.	1.514216
F-statistic	1.386937	Durbin-Watson stat	2.297424
Prob(F-statistic)	0.262869		

Observations from table 4.25 indicate that the quadratic model developed has some degree of explanatory powers. This is indicated by an R^2 value of 0.07. The coefficients as well are fairly significant indicating that there is some quadratic relationship between the first differences of unemployment rate and construction output in Kenya.

Table 4.25 presents the coefficients of quadratic regression of the differenced logarithm of construction output levels and differenced Unemployment rate. These regression coefficients as obtained from the table are:

- 0.47 for unemployment rate (UNEMPR)
- -0.02 for unemployment rate squared $(UNEMPR)^2$

It can now be observed from the integers listed above that one coefficient is negative and the other is positive. This is an implication that one explanatory variable tends to decrease construction output in the country and the other tends to decrease it. It is therefore seen that all these explanatory variables present results which are consistence with the basic economic theory and a priori regardless of whether the coefficient is negative or positive. Therefore, based on these results as earlier displayed in table 4.25, the following equation is now formed: -

$dlogCO_t = 0.18 + 0.47 \times dUNEMPR_t - 0.02x\ dUNEMPR_t \times dUNEMPR_t$ ....(21)

Where: -

$dlogCO_t = logCO_t - logCO_{t-1}$ (for first difference of logarithm of construction output (CO)

$dUNEMPR_t = UNEMPR_t - UNEMPR_{t-1}$ (for the first differences of Unemployment Rate (UNEMPR)

When the equation is expressed in terms of levels of variables, it appears as given below:

$logCO_t - logCO_{t-1} = 0.18 + 0.47 \times (UNEMPR_t - UNEMPR_{t-1}) - 0.02 \times (UNEMPR_t - UNEMPR_{t-1}) \times (UNEMPR_t - UNEMPR_{t-1})$

Putting the like terms together and opening up the brackets, the equation is organized as follows: -

$LogCO_t = 0.18 + LogCO_{t-1} + 0.47UNEMPR_t - 0.47UNEMPR_{t-1} - 0.04(UNEMPR_t x UNEMPR_{t-1}) + 0.02(UNEMPR_t)^2 + 0.02(UNEMPR_{t-1})^2$

Finally, a quadratic model which describes Kenya's construction industry in relation to unemployment rate is now developed as below: -

$$\mathbf{LogCO_t = 0.18 + LogCO_{t-1} + 0.47UNEMPR_t - 0.47UNEMPR_{t-1} + 0.04(UNEMPR_t x UNEMPR_{t-1}) + 0.02(UNEMPR_t)^2 + 0.02(UNEMPR_{t-1})^2} \ldots\ldots \quad \mathbf{(22)}$$

The quadratic equation developed above means that construction output level in a specific year depends upon (i) construction output levels in the previous year, (ii) unemployment rate in the current and previous year (iii) unemployment rate in the current year multiplied by the rate in the previous year (iv) square of the current unemployment rate and the square of the unemployment rate in the previous year. The model is consistent with a priori and the basic economic theory and hence gives a clear picture of the actual economic impact of unemployment rate on construction output levels in Kenya.

4.8.1.5 Quadratic Regression of population growth rate (POPGR) on Construction Output (CO)

The second differences of population growth Rates were regressed on the first differences of Kenya's annual Construction Output using the following quadratic regression equation:

$$\mathbf{CO_t} = \alpha + \beta_1(\mathbf{POPGR_t}) + \beta_2(\mathbf{POPGR_t})^2 + \varepsilon_t \ldots\ldots\ldots\ldots \quad \mathbf{(23)}$$

The quadratic regression results of the above model are as displayed in table 4.26.

Table 4.26: Quadratic Regression Results of differenced POPGR on Differenced CO

Dependent Variable: DLOG(CO)
Method: Least Squares
Date: 08/10/20 Time: 23:04
Sample (adjusted): 1979 2016
Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.305095	0.099624	3.062465	0.0042
D(POPGR,2)	3.105580	5.938376	0.522968	0.6043
D(POPGR,2)^2	-401.3160	302.7905	-1.325392	0.1936

R-squared	0.070847	Mean dependent var	0.214547
Adjusted R-squared	0.017753	S.D. dependent var	0.497171
S.E. of regression	0.492738	Akaike info criterion	1.497980
Sum squared resid	8.497686	Schwarz criterion	1.627263
Log likelihood	-25.46161	Hannan-Quinn criter.	1.543978
F-statistic	1.334363	Durbin-Watson stat	2.280936
Prob(F-statistic)	0.276391		

The observations from table 4.26 indicate that the quadratic model has some good degree of explanatory powers. This is due to the observed R^2 value of 0.07. The coefficients as well are quite significant indicating that there is some quadratic relationship between the second differences of population growth rate and construction output in Kenya.

The results as given in table 4.26 presents the coefficients of quadratic regression of the differenced logarithm of construction output levels and differenced population growth rate. These regression coefficients as obtained from the above table are:

- 3.1 for population growth Rate (POPGR)
- -401.3 for population growth rate squared $(POPGR)^2$

It can now be observed from the integers listed above that one coefficient is negative and the other is positive. This is an implication that one explanatory variable tends to increase construction output in the country and the other tends to decrease it. It is therefore seen that all these explanatory variables present results which are consistence with the basic economic theory and a priori regardless of whether the coefficient is negative or positive. Therefore, based on these results as displayed in table 4.25, the following equation is formed: -

$$\mathbf{dlogCO_t = 0.31 + 3.1 \times d2POPGR_t - 401.3 \times d2POPGR_t \times d2POPGR_t \ldots\ldots\ldots\ldots (24)}$$

Where: -

$dlogCO_t = logCO_t - logCO_{t-1}$ (for first difference of logarithm of construction output (CO)

$d2POPGR_t = POPGR_t - POPGR_{t-1} - POPGR_{t-2}$ (for the second differences of population growth Rate (POPGR)

When the equation is expressed in terms of levels of variables, it appears as given below:

$$logCO_t - logCO_{t-1} = 0.31 + 3.1 \times (POPGR_t - POPGR_{t-1} - POPGR_{t-2}) - 401.3 \times (POPGR_t - POPGR_{t-1} - POPGR_{t-2}) \times (POPGR_t - POPGR_{t-1} - POPGR_{t-2})$$

Putting the like terms together and opening up the brackets, the equation is organized as follows: -

$$LogCO_t = 0.31 + LogCO_{t-1} + 3.1POPGR_t - 3.1POPGR_{t-1} - 3.1POPGR_{t-2} - 401.3(POPGR_t)^2 - (POPGR_tPOPGR_{t-1}) - POPGR_tPOPGR_{t-2} - POPGR_{t-1}POPGR_t + (POPGR_{t-1})^2 + POPGR_{t-1}POPGR_{t-2} - POPGR_{t-2}POPGR_t + POPGR_{t-2}POPGR_{t-1} + (POPGR_{t-2})^2$$

Finally, a quadratic model which describes Kenya's construction industry in relation to population growth rate is now developed as below: -

$$\mathbf{LogCO_t = 0.31 + LogCO_{t-1} + 3.1POPGR_t - 3.1POPGR_{t-1} - 3.1POPGR_{t-2} - 401.3(POPGR_t)^2 - 401.3\ (POPGR_tPOPGR_{t-1}) - 401.3POPGR_tPOPGR_{t-2} - 401.3POPGR_{t-1}POPGR_t + 401.3\ (POPGR_{t-1})^2 + 401.3POPGR_{t-1}POPGR_{t-2} - 401.3POPGR_{t-2}POPGR_t + 401.3POPGR_{t-2}POPGR_{t-1} + 401.3(POPGR_{t-2})^2} \quad \ldots\ldots \quad \mathbf{(25)}$$

The quadratic equation developed above means that construction output level in a specific year depends upon (i) construction output levels in the previous year, (ii) population growth rate in the current and previous two years (iii) population growth rate in the current year multiplied by the rate in the previous two years (iv) square of the current population growth rate and the square of the unemployment rate in the previous two years. The model is consistent with a priori and the basic economic theory and hence gives a clear picture of the actual economic impact of population growth rate on construction output levels in Kenya.

4.8.2 Exponential Regression of Construction output on Macro-Economic Factors

In general, an exponential function or model takes the form:

$$\mathbf{Y_t = e^{\beta 1 + \beta 2Xt + \beta 3Xt}} \quad \ldots\ldots \quad \mathbf{(26)}$$

Where,

$\mathbf{Y_t}$ = Dependent Variable at a given year

X = Independent variables

β = Regression coefficients

t = A given time period

e = Constant (Euler's number)

As regards this research thesis, the five (5) explanatory variables and the dependent variable are put together to form an exponential regression model as formulated below.

$$CO_t = e^{\alpha + \beta 1(CBWRt) + \beta 2(IRt) + \beta 3(ERt) + \beta 4(UNEMPRt) + \beta 5(POPGRt) + \varepsilon t}$$

……….(27)

The regression of the exponential function of macroeconomic factors and construction output is carried out and their regression parameters observed as seen in table 4.27.

Table 4.27: Exponential Regression Results

Dependent Variable: DLOG(CO)
Method: Generalized Linear Model (Newton-Raphson / Marquardt steps)
Sample (adjusted): 1979 2016
Included observations: 38 after adjustments
Family: Exponential Mean Quasi-likelihood
Link: Identity
Dispersion computed using Pearson Chi-Square
Convergence achieved after 5 iterations
Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.221389	0.089488	2.473943	0.0134
D(CBWR)	0.032704	0.030037	1.088778	0.2763
D(IR)	-0.006855	0.011915	-0.575350	0.5651
D(ER)	-0.009409	0.017012	-0.553052	0.5802
D(UNEMPR)	0.400733	0.259562	1.543881	0.1226
D(POPGR,2)	7.529245	6.035165	1.247562	0.2122

Mean dependent var	0.214547	S.D. dependent var	0.497171
Sum squared resid	7.977706	Quasi-log likelihood	182.8456
Deviance	4.059582	Deviance statistic	0.126862
Restr. deviance	4.994104	Quasi-LR statistic	5.489069
Prob(Quasi-LR stat)	0.359146	Pearson SSR	5.448044

Pearson statistic	0.170251	Dispersion	0.170251

From the above exponential regression results' table, the coefficient estimates indicate that the first differences of commercial banks weighted interest rate (CBWR), the first differences of unemployment rate (UNEMPR) and the second differences of population growth rate are positively related to construction output variations, and that the relationship is statistically significant at conventional levels for the first differences of unemployment rate (UNEMPR) and the second differences of population growth rate (POPGR). The first difference of inflation rate (IR) and US dollar to Kenya shillings exchange rate (ER) are negatively related to first difference of construction output (CO) variations in Kenya but this relationship is not statistically significant. The same applies to first differences of commercial banks weighted interest rates (CBWR) even though it is positively related to the first differences of construction output levels in Kenya.

Therefore, on the basis of these results as earlier displayed in table 4.26, the following equation is now formed: -

$$\mathbf{dlogCO_t = 0.22 + 0.03 \times dCBWR_t - 0.4 \times dUNEMPR_t - 0.01 \times dIR_t + 7.5 \times 2dPOPGR_t - 0.01 \times dER_t} \quad \textbf{(28)}$$

Where: -

$dlogCO_t = logCO_t - logCO_{t-1}$ (for first difference of logarithm of construction output (CO)

$dCBWR_t = CBWR_t - CBWR_{t-1}$ (for the first differences of Commercial Banks' Weighted Interest Rate (CBWR)

$dUNEMPR_t = UNEMPR_t - UNEMPR_{t-1}$ (for the first differences of Unemployment Rate (UNEMPR)

$dIR_t = IR_t - IR_{t-1}$ (for the first differences of Inflation Rate (IR)

$2dPOPGR_t = POPGR_t - POPGR_{t-1} - POPGR_{t-2}$ (for the second differences of Population Growth Rate (POPGR)

$dER_t = ER_t - ER_{t-1}$ (for the first differences of the US Dollar to Kenya Shilling Exchange Rate (ER)

When the equation is expressed in terms of levels of variables, it appears as follows: -

$logCO_t - logCO_{t-1} = 0.22 + 0.03 \times (CBWR_t - CBWR_{t-1}) - 0.4 \times (UNEMPR_t - UNEMPR_{t-1}) - 0.01 \times (IR_t - IR_{t-1}) + 7.5 \times (POPGR_t - POPGR_{t-1} - POPGR_{t-2}) - 0.01 \times (ER_t - ER_{t-1})$

The like terms are put together and the equation organized to obtain the following: -

$LogCO_t = 0.22 + LogCO_{t-1} + 0.03CBWR_t - 0.03CBWR_{t-1} - 0.4UNEMPR_t + 0.4UNEMPR_{t-1} - 0.01IR_t + 0.01IR_{t-1} + 7.5POPGR_t - 7.5POPGR_{t-1} - 7.5\ POPGR_{t-2} - 0.01ER_t + 0.01ER_{t-1}$

Finally, an exponential model which describes Kenya's construction industry in relation to the macro- economic factors is now developed as below: -

$$\mathbf{LogCO_t = 0.22 + LogCO_{t-1} + 0.03CBWR_t - 0.03CBWR_{t-1} - 0.4UNEMPR_t + 0.4UNEMPR_{t-1} - 0.01IR_t + 0.01IR_{t-1} + 7.5POPGR_t - 7.5POPGR_{t-1} - 7.5\ POPGR_{t-2} - 0.01ER_t + 0.01ER_{t-1}} \quad \textbf{(29)}$$

The above exponential equation carries a meaning that construction output level in a specific year depends upon (i) construction output levels in the previous year, (ii) unemployment rate in the current and the previous year, (iii) inflation rate in the current and the previous year (iv) population growth rate in the current and the previous two (2) years (v) US Dollar to Kenya Shillings exchange rate in the current and the previous year and (vi) Commercial banks weighted interest rates in the current year and the previous year. The model is consistent with a priori and the basic economic theory. It therefore gives a clear picture of the actual economic behavior of the industry in Kenya based on the five (5) macro-economic factors.

4.9 Cointegration

The presence of cointegration in time series variables necessitates the use of a restricted vector auto-regression (VAR) designed for use with nonstationary time series. The researcher decided to develop the VAR model after realizing the six (6) variables' data could be cointegrated. Therefore, to ascertain the presence of cointegration, firstly, the cointegration test was carried out.

4.9.1 Cointegration Test

This test was carried out on all the economic variables in this research except one. This was population growth rate (POPGR) which is integrated of order two I (2). This means that the second differences of this variable are stationary. For this reason, it was left out in this test since it is a requirement that a variable should be integrated of order one I (1) to qualify for inclusion in this test. The rest of the variables are integrated of order one, which implies that their first differences are stationary and therefore they are included in the test. This is also observed in the stationarity tests and transformations in section 4.4 of this research.

Prior to carrying out the actual cointegration test, it was realized that lag selection process had to be performed for purposes of guiding on the specific number of lags to be included in the model. The lag selection process was initiated by estimating an unrestricted VAR which formed the basis of the lag selection criteria. The standard VAR results which paved way for lag selection criteria are given in the table below:

Table 4.28: Vector Auto-regression (VAR) Results

Standard errors in ( ) & t-statistics in [ ]

	LOG(CO)	CBWR	IR	ER	UNEMPR
LOG(CO(-1))	0.357605	-0.466927	4.207088	1.476023	0.076482
	(0.17356)	(1.23537)	(3.77881)	(2.70460)	(0.13129)
	[2.06042]	[-0.37796]	[1.11334]	[0.54575]	[0.58256]
LOG(CO(-2))	-0.100822	-0.193919	0.583368	1.269381	-0.106647
	(0.15633)	(1.11272)	(3.40365)	(2.43608)	(0.11825)
	[-0.64494]	[-0.17427]	[0.17139]	[0.52107]	[-0.90185]
CBWR(-1)	-0.086640	0.412828	-0.060452	-0.128454	-0.037970
	(0.03265)	(0.23237)	(0.71077)	(0.50872)	(0.02469)
	[-2.65394]	[1.77662]	[-0.08505]	[-0.25250]	[-1.53760]
CBWR(-2)	0.046233	0.373345	0.462160	0.504369	0.031588
	(0.02715)	(0.19322)	(0.59104)	(0.42302)	(0.02053)
	[1.70310]	[1.93220]	[0.78195]	[1.19230]	[1.53829]
IR(-1)	0.019879	0.162493	0.470790	0.076358	0.020036
	(0.01212)	(0.08628)	(0.26391)	(0.18888)	(0.00917)
	[1.64007]	[1.88340]	[1.78393]	[0.40426]	[2.18523]
IR(-2)	-0.014531	0.017973	0.014325	-0.059270	-0.005263
	(0.00987)	(0.07028)	(0.21499)	(0.15387)	(0.00747)
	[-1.47164]	[0.25572]	[0.06663]	[-0.38519]	[-0.70465]
ER(-1)	0.006918	0.202639	0.019612	0.937325	-0.003705
	(0.01412)	(0.10053)	(0.30750)	(0.22009)	(0.01068)
	[0.48984]	[2.01574]	[0.06378]	[4.25891]	[-0.34684]
ER(-2)	0.050569	-0.173913	-0.458794	-0.171744	0.010437
	(0.01783)	(0.12691)	(0.38820)	(0.27785)	(0.01349)
	[2.83614]	[-1.37034]	[-1.18184]	[-0.61812]	[0.77386]
UNEMPR(-1)	0.407956	-0.570779	-4.919856	0.344962	0.913769
	(0.25994)	(1.85024)	(5.65959)	(4.05072)	(0.19663)
	[1.56940]	[-0.30849]	[-0.86930]	[0.08516]	[4.64712]
UNEMPR(-2)	0.081309	1.237132	2.811019	-2.140588	0.072857
	(0.24971)	(1.77741)	(5.43681)	(3.89127)	(0.18889)
	[0.32561]	[0.69603]	[0.51703]	[-0.55010]	[0.38571]
R-squared	0.988248	0.873660	0.322716	0.972366	0.964271
Adj. R-squared	0.984471	0.833051	0.105018	0.963483	0.952786
Sum sq. resids	3.909682	198.0799	1853.340	949.4016	2.237124
S.E. equation	0.373673	2.659753	8.135767	5.822989	0.282661
F-statistic	261.6192	21.51381	1.482401	109.4707	83.96373
Log likelihood	-10.71119	-85.29027	-127.7757	-115.0663	-0.104155
Akaike AIC	1.090063	5.015277	7.251351	6.582439	0.531798
Schwarz SC	1.521007	5.446221	7.682295	7.013382	0.962741
Mean dependent	7.784369	18.30684	12.16263	53.17868	7.642895

S.D. dependent	2.998568	6.509522	8.599859	30.47197	1.300866

Determinant resid covariance (dof adj.)	59.87442
Determinant resid covariance	13.00509
Log likelihood	-318.3398
Akaike information criterion	19.38631
Schwarz criterion	21.54102
Number of coefficients	50

The lags included in the VAR model estimates as shown in the results displayed in table 4.28 are two (2) for each variable for just providing a basis from where the suitable lag lengths are selected.

4.9.2 Lag selection Criteria

This is a very important process since the lags have an impact on serial correlation of the residuals of the model. Therefore, if it is carried out subjectively, the eventual results may be misleading. Results of the lag selection process are displayed in the table 4.29 overleaf.

Table 4.29: VAR Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: CO CBWR IR ER UNEMPR
Exogenous variables: C
Date: 08/15/20 Time: 19:18
Sample: 1977 2016
Included observations: 36

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-874.0740	NA	1.12e+15	48.83744	49.05738	48.91420
1	-699.2787	291.3254	2.75e+11	40.51549	41.83508*	40.97606
2	-679.0861	28.04526	3.92e+11	40.78256	43.20183	41.62695
3	-642.1075	41.08736	2.54e+11	40.11708	43.63602	41.34529
4	-594.5895	39.59835*	1.21e+11*	38.86608*	43.48468	40.47810*

* 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

In the process of development of a Vector error correction model (VECM) for cointegrated variables in this research, it was important to first select the lags to be included in the model. For that reason, vector auto-regression order selection criteria were used and lags up to four (4) were identified as the best and most suited for inclusion in this model. These results of the lag order selection criteria are given in table 4.29.

4.9.3 Johansen Test of Cointegration

The Johansen cointegration test used in this test converts the data of the time series to their first differences automatically. Otherwise, the test results may not be accurate. Presence of cointegration amongst the variables leads to application of correction measures to remove the long-term association of the variables. In this case, vector error correction model (VECM) is used. Table 4.29 presents the Johansen Cointegration test results for construction output and the four (4) macro-economic variables which are integrated of order one I(1). The macro-economic factors are CBWR, IR, UNEMPR and ER.

Table 4.30: Johansen Cointegration Test for construction output and Macro-Economic Factors

Sample (adjusted): 1982 2016
Included observations: 35 after adjustments
Trend assumption: Linear deterministic trend
Series: CO CBWR IR ER UNEMPR
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.962741	282.3349	69.81889	0.0001
At most 1 *	0.902953	167.1894	47.85613	0.0000
At most 2 *	0.761975	85.54983	29.79707	0.0000
At most 3 *	0.427758	35.31162	15.49471	0.0000
At most 4 *	0.362824	15.77485	3.841466	0.0001

Trace test indicates 5 cointegrating eqn (s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.962741	115.1455	33.87687	0.0000
At most 1 *	0.902953	81.63960	27.58434	0.0000
At most 2 *	0.761975	50.23821	21.13162	0.0000
At most 3 *	0.427758	19.53677	14.26460	0.0067
At most 4 *	0.362824	15.77485	3.841466	0.0001

Max-eigenvalue test indicates 5 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

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

CO	CBWR	IR	ER	UNEMPR
-0.000275	-1.088992	-0.552020	0.415351	-1.720656
2.44E-05	1.267013	0.115529	-0.401496	10.06892
-6.79E-05	0.341613	-0.053727	-0.126679	2.902358
0.000182	-0.178799	-0.462250	0.020121	-5.125653
-0.000187	-0.674384	-0.736201	0.403147	-4.734199

Unrestricted Adjustment Coefficients (alpha):

1 Cointegrating Equation(s): Log likelihood -553.3983

Normalized cointegrating coefficients (standard error in parentheses)

CO	CBWR	IR	ER	UNEMPR
1.000000	3960.084	2007.404	-1510.409	6257.106
	(301.887)	(174.649)	(104.498)	(2509.22)

Adjustment coefficients (standard error in parentheses)

D(CO)	-2.461268
	(0.49487)
D(CBWR)	-6.95E-05
	(0.00014)
D(IR)	9.08E-05
	(0.00045)
D(ER)	0.000234
	(0.00026)
D(UNEMPR)	-2.78E-05
	(1.6E-05)

2 Cointegrating Equation(s): Log likelihood -512.5785

Normalized cointegrating coefficients (standard error in parentheses)

CO	CBWR	IR	ER	UNEMPR
1.000000	0.000000	1781.972	-276.5776	-27291.17
		(275.658)	(49.5646)	(1345.41)
0.000000	1.000000	0.056926	-0.311567	8.471606
		(0.05716)	(0.01028)	(0.27896)

Adjustment coefficients (standard error in parentheses)

D(CO)	-2.346682	-3786.165
	(0.34215)	(2070.59)
D(CBWR)	-9.71E-05	-1.711506
	(0.00011)	(0.64329)
D(IR)	1.65E-05	-3.506840
	(0.00038)	(2.32039)
D(ER)	0.000220	0.183664
	(0.00026)	(1.58116)
D(UNEMPR)	-2.80E-05	-0.120943
	(1.6E-05)	(0.09650)

3 Cointegrating Equation(s): Log likelihood -487.4594

Normalized cointegrating coefficients (standard error in parentheses)

CO	CBWR	IR	ER	UNEMPR
1.000000	0.000000	0.000000	1178.686	41487.78
			(611.808)	(18834.1)
0.000000	1.000000	0.000000	-0.265078	10.66879
			(0.02349)	(0.72323)
0.000000	0.000000	1.000000	-0.816659	-38.59710
			(0.34907)	(10.7459)

Adjustment coefficients (standard error in parentheses)

D(CO)	-2.339428	-3822.676	-4391.511
	(0.35224)	(2112.83)	(701.937)
D(CBWR)	-9.00E-05	-1.747150	-0.264896
	(0.00011)	(0.65474)	(0.21752)
D(IR)	1.54E-05	-3.501431	-0.171047
	(0.00039)	(2.36839)	(0.78684)
D(ER)	0.000336	-0.397846	0.494015
	(0.00023)	(1.39872)	(0.46469)
D(UNEMPR)	-1.61E-05	-0.180611	-0.047332
	(8.9E-06)	(0.05364)	(0.01782)

4 Cointegrating Equation(s): Log likelihood -477.6910

Normalized cointegrating coefficients (standard error in parentheses)

CO	CBWR	IR	ER	UNEMPR
1.000000	0.000000	0.000000	0.000000	-12977.06
				(2764.88)
0.000000	1.000000	0.000000	0.000000	22.91753
				(3.18567)

0.000000	0.000000	1.000000	0.000000	-0.860835
				(1.03551)
0.000000	0.000000	0.000000	1.000000	46.20810
				(10.0902)

Adjustment coefficients (standard error in parentheses)

D(CO)	-1.985061	-4171.717	-5293.890	1881.502
	(0.37590)	(1910.84)	(814.868)	(659.473)
D(CBWR)	-1.26E-05	-1.823472	-0.462213	0.581918
	(0.00012)	(0.62625)	(0.26706)	(0.21613)
D(IR)	0.000597	-4.074612	-1.652895	1.150543
	(0.00036)	(1.82945)	(0.78016)	(0.63138)
D(ER)	0.000667	-0.723878	-0.348879	0.134248
	(0.00022)	(1.10725)	(0.47218)	(0.38213)
D(UNEMPR)	-2.20E-05	-0.174845	-0.032426	0.066894
	(1.0E-05)	(0.05170)	(0.02205)	(0.01784)

Johansen cointegration test results for the five (5) variables are displayed in table 4.30 above. These results confirm that indeed the time series variables' data are cointegrated meaning they have long term association.

As observed from the table, the null hypothesis that there are no cointegrating equations was not accepted. The unrestricted cointegration test using trace test indicates that, at least there are four (4) cointegrating equations. Similarly, Eigen maximum value test indicate that at least there are also four (4) cointegrating equations. Therefore, the null hypothesis that none of the variables are cointegrated is rejected at 0.05 level of confidence. This is an indication that most of the variables are cointegrated since a number of the p-values are less than 0.05. This means that the variables have long run association and hence the need to run a restricted vector autoregressive (VAR) model or vector error correction (VECM) model.

4.9.4 Vector Error Correction Model

This is a restricted Vector Auto-regression (VAR) which is specifically designed for use with known cointegrated time series which are unstationary. It requires that the entire number of variables included in this model be integrated of order one I (1). In order to agree with this requirement, one variable which is integrated of order two I (2) was left out and the number of explanatory variables dropped to four. They are namely commercial banks weighted interest rates (CBWR), US dollar to Kenya shilling exchange rate (ER), unemployment rate (UNEMPR) and inflation rate (IR). These variables are included in the restricted VAR model where logarithm of construction output (LogCO) is regressed on them.

The output of the restricted VAR process generated five (5) models from which the model of interest to this research was selected. The list of the five (5) models as they were generated by the system is given below:

1) D(LOG(CO)) = C(1)*(LOG(CO(-1)) - 1.70478425066*UNEMPR(-1) + 5.16006579703) + C(2)*(CBWR(-1) + 3.15398362602*UNEMPR(-1) - 42.8698396895) + C(3)*(IR(-1) + 2.59685706694*UNEMPR(-1) - 32.2070007271) + C(4)*(ER(-1) - 11.9191124354*UNEMPR(-1) + 36.4942249571) + C(5)*D(LOG(CO(-1))) + C(6)*D(LOG(CO(-2))) + C(7)*D(LOG(CO(-3))) + C(8)*D(LOG(CO(-4))) + C(9)*D(CBWR(-1)) + C(10)*D(CBWR(-2)) + C(11)*D(CBWR(-3)) + C(12)*D(CBWR(-4)) + C(13)*D(IR(-1)) + C(14)*D(IR(-2)) + C(15)*D(IR(-3)) + C(16)*D(IR(-4)) + C(17)*D(ER(-1)) + C(18)*D(ER(-2)) + C(19)*D(ER(-3)) + C(20)*D(ER(-4)) + C(21)*D(UNEMPR(-1)) + C(22)*D(UNEMPR(-2)) + C(23)*D(UNEMPR(-3)) + C(24)*D(UNEMPR(-4)) + C(25)
2) D(CBWR) = C(26)*(LOG(CO(-1)) - 1.70478425066*UNEMPR(-1) + 5.16006579703) + C(27)*(CBWR(-1) + 3.15398362602*UNEMPR(-1) - 42.8698396895) + C(28)*(IR(-1) + 2.59685706694*UNEMPR(-1) - 32.2070007271) + C(29)*(ER(-1) - 11.9191124354*UNEMPR(-1) + 36.4942249571) + C(30)*D(LOG(CO(-1))) + C(31)*D(LOG(CO(-2))) + C(32)*D(LOG(CO(-3))) + C(33)*D(LOG(CO(-4))) + C(34)*D(CBWR(-1)) + C(35)*D(CBWR(-2)) + C(36)*D(CBWR(-3)) + C(37)*D(CBWR(-4)) + C(38)*D(IR(-1)) + C(39)*D(IR(-2)) + C(40)*D(IR(-3)) + C(41)*D(IR(-4)) + C(42)*D(ER(-1)) + C(43)*D(ER(-2)) + C(44)*D(ER(-3)) + C(45)*D(ER(-4)) + C(46)*D(UNEMPR(-1)) + C(47)*D(UNEMPR(-2)) + C(48)*D(UNEMPR(-3)) + C(49)*D(UNEMPR(-4)) + C(50)
3) D(IR) = C(51)*(LOG(CO(-1)) - 1.70478425066*UNEMPR(-1) + 5.16006579703) + C(52)*(CBWR(-1) + 3.15398362602*UNEMPR(-1) - 42.8698396895) + C(53)*(IR(-1) + 2.59685706694*UNEMPR(-1) - 32.2070007271) + C(54)*(ER(-1) - 11.9191124354*UNEMPR(-1) + 36.4942249571) + C(55)*D(LOG(CO(-1))) + C(56)*D(LOG(CO(-2))) + C(57)*D(LOG(CO(-3))) + C(58)*D(LOG(CO(-4))) + C(59)*D(CBWR(-1)) + C(60)*D(CBWR(-2)) + C(61)*D(CBWR(-3)) + C(62)*D(CBWR(-4)) + C(63)*D(IR(-1)) + C(64)*D(IR(-2)) + C(65)*D(IR(-3)) + C(66)*D(IR(-4)) + C(67)*D(ER(-1)) + C(68)*D(ER(-2)) + C(69)*D(ER(-3)) + C(70)*D(ER(-4)) + C(71)*D(UNEMPR(-1)) + C(72)*D(UNEMPR(-2)) + C(73)*D(UNEMPR(-3)) + C(74)*D(UNEMPR(-4)) + C(75)
4) D(ER) = C(76)*(LOG(CO(-1)) - 1.70478425066*UNEMPR(-1) + 5.16006579703) + C(77)*(CBWR(-1) + 3.15398362602*UNEMPR(-1) - 42.8698396895) + C(78)*(IR(-1) +

2.59685706694*UNEMPR(-1) - 32.2070007271) + C(79)*(ER(-1) - 11.9191124354*UNEMPR(-1) + 36.4942249571) + C(80)*D(LOG(CO(-1))) + C(81)*D(LOG(CO(-2))) + C(82)*D(LOG(CO(-3))) + C(83)*D(LOG(CO(-4))) + C(84)*D(CBWR(-1)) + C(85)*D(CBWR(-2)) + C(86)*D(CBWR(-3)) + C(87)*D(CBWR(-4)) + C(88)*D(IR(-1)) + C(89)*D(IR(-2)) + C(90)*D(IR(-3)) + C(91)*D(IR(-4)) + C(92)*D(ER(-1)) + C(93)*D(ER(-2)) + C(94)*D(ER(-3)) + C(95)*D(ER(-4)) + C(96)*D(UNEMPR(-1)) + C(97)*D(UNEMPR(-2)) + C(98)*D(UNEMPR(-3)) + C(99)*D(UNEMPR(-4)) + C(100)

5) D(UNEMPR) = C(101)*(LOG(CO(-1)) - 1.70478425066*UNEMPR(-1) + 5.16006579703) + C(102)*(CBWR(-1) + 3.15398362602*UNEMPR(-1) - 42.8698396895) + C(103)*(IR(-1) + 2.59685706694*UNEMPR(-1) - 32.2070007271) + C(104)*(ER(-1) - 11.9191124354*UNEMPR(-1) + 36.4942249571) + C(105)*D(LOG(CO(-1))) + C(106)*D(LOG(CO(-2))) + C(107)*D(LOG(CO(-3))) + C(108)*D(LOG(CO(-4))) + C(109)*D(CBWR(-1)) + C(110)*D(CBWR(-2)) + C(111)*D(CBWR(-3)) + C(112)*D(CBWR(-4)) + C(113)*D(IR(-1)) + C(114)*D(IR(-2)) + C(115)*D(IR(-3)) + C(116)*D(IR(-4)) + C(117)*D(ER(-1)) + C(118)*D(ER(-2)) + C(119)*D(ER(-3)) + C(120)*D(ER(-4)) + C(121)*D(UNEMPR(-1)) + C(122)*D(UNEMPR(-2)) + C(123)*D(UNEMPR(-3)) + C(124)*D(UNEMPR(-4)) + C(125)

The restricted VAR regression model below was identified and selected from the list of five models generated by the restricted VAR.

D(LOG(CO)) = C(1)*(LOG(CO(-1)) - 1.70478425066*UNEMPR(-1) + 5.16006579703) + C(2)*(CBWR(-1) + 3.15398362602*UNEMPR(-1) - 42.8698396895) + C(3)*(IR(-1) + 2.59685706694*UNEMPR(-1) - 32.2070007271) + C(4)*(ER(-1) - 11.9191124354*UNEMPR(-1) + 36.4942249571) + C(5)*D(LOG(CO(-1))) + C(6)*D(LOG(CO(-2))) + C(7)*D(LOG(CO(-3))) + C(8)*D(LOG(CO(-4))) + C(9)*D(CBWR(-1)) + C(10)*D(CBWR(-2)) + C(11)*D(CBWR(-3)) + C(12)*D(CBWR(-4)) + C(13)*D(IR(-1)) + C(14)*D(IR(-2)) + C(15)*D(IR(-3)) + C(16)*D(IR(-4)) + C(17)*D(ER(-1)) + C(18)*D(ER(-2)) + C(19)*D(ER(-3)) + C(20)*D(ER(-4)) + C(21)*D(UNEMPR(-1)) + C(22)*D(UNEMPR(-2)) + C(23)*D(UNEMPR(-3)) + C(24)*D(UNEMPR(-4)) +C(25) …………………………………………………………...............................(30)

This system equation model was used for this restricted vector auto-regression model (VECM). The results of the auto-regression are as displayed by the VECM auto-regression output below:

Table 4.31: Results for Vector Error Correction Model (VECM)

Vector Error Correction Estimates
Date: 08/15/20 Time: 22:11
Sample (adjusted): 1982 2016
Included observations: 35 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4	
LOG(CO(-1))	1.000000	0.000000	0.000000	0.000000	
CBWR(-1)	0.000000	1.000000	0.000000	0.000000	
IR(-1)	0.000000	0.000000	1.000000	0.000000	
ER(-1)	0.000000	0.000000	0.000000	1.000000	
UNEMPR(-1)	-1.704784	3.153984	2.596857	-11.91911	
	(0.18684)	(0.92933)	(0.74022)	(3.24174)	
	[-9.12418]	[3.39384]	[3.50821]	[-3.67677]	
C	5.160066	-42.86984	-32.20700	36.49422	
Error Correction:	**D(LOG(CO))**	**D(CBWR)**	**D(IR)**	**D(ER)**	**D(UNEMPR)**
CointEq1	-1.860086	-21.90349	-68.68135	-37.55715	0.453568
	(0.83191)	(4.78068)	(18.0409)	(13.3537)	(0.89864)
	[-2.23592]	[-4.58167]	[-3.80697]	[-2.81250]	[0.50473]
CointEq2	-0.090389	-1.555863	-4.877416	-1.482128	-0.071773
	(0.05662)	(0.32536)	(1.22781)	(0.90881)	(0.06116)
	[-1.59649]	[-4.78199]	[-3.97245]	[-1.63085]	[-1.17355]
CointEq3	0.049816	0.983646	1.615706	1.476718	0.018012
	(0.04510)	(0.25915)	(0.97797)	(0.72388)	(0.04871)
	[1.10466]	[3.79560]	[1.65210]	[2.04000]	[0.36974]
CointEq4	0.135423	1.600945	5.286895	2.631413	-0.000577
	(0.05829)	(0.33497)	(1.26409)	(0.93566)	(0.06297)
	[2.32325]	[4.77932]	[4.18236]	[2.81235]	[-0.00916]
D(LOG(CO(-1)))	0.624200	14.26873	44.96794	23.20497	-0.412395
	(0.58636)	(3.36958)	(12.7158)	(9.41209)	(0.63339)
	[1.06454]	[4.23457]	[3.53637]	[2.46544]	[-0.65109]
D(LOG(CO(-2)))	0.192010	8.718306	33.67687	15.61194	-0.388226
	(0.37894)	(2.17762)	(8.21771)	(6.08264)	(0.40933)
	[0.50670]	[4.00359]	[4.09808]	[2.56664]	[-0.94844]
D(LOG(CO(-3)))	-0.233131	1.660669	4.417267	-1.077636	-0.376334
	(0.17889)	(1.02804)	(3.87951)	(2.87156)	(0.19324)
	[-1.30318]	[1.61538]	[1.13861]	[-0.37528]	[-1.94747]
D(LOG(CO(-4)))	0.160631	-1.566914	-7.998970	-8.074040	-0.135961
	(0.15119)	(0.86883)	(3.27872)	(2.42687)	(0.16332)

	[1.06245]	[-1.80347]	[-2.43966]	[-3.32694]	[-0.83250]
D(CBWR(-1))	-0.054510	0.130659	2.283046	-1.016307	-0.026081
	(0.06372)	(0.36619)	(1.38188)	(1.02285)	(0.06883)
	[-0.85543]	[0.35681]	[1.65213]	[-0.99360]	[-0.37890]
D(CBWR(-2))	-0.021744	-0.109286	-0.304878	-2.518689	0.002115
	(0.07614)	(0.43755)	(1.65119)	(1.22219)	(0.08225)
	[-0.28558]	[-0.24977]	[-0.18464]	[-2.06080]	[0.02572]
D(CBWR(-3))	-0.010520	-0.283956	-0.350797	-0.017235	0.071739
	(0.06358)	(0.36537)	(1.37881)	(1.02058)	(0.06868)
	[-0.16546]	[-0.77717]	[-0.25442]	[-0.01689]	[1.04454]
D(CBWR(-4))	-0.026610	-0.460965	-1.609919	0.182763	0.042765
	(0.04546)	(0.26122)	(0.98579)	(0.72967)	(0.04910)
	[-0.58539]	[-1.76463]	[-1.63313]	[0.25047]	[0.87093]
D(IR(-1))	-0.004017	-0.778884	-2.332242	-0.794238	0.004863
	(0.03489)	(0.20051)	(0.75665)	(0.56006)	(0.03769)
	[-0.11512]	[-3.88459]	[-3.08231]	[-1.41812]	[0.12903]
D(IR(-2))	0.020291	-0.339342	-0.818709	0.124255	-0.001885
	(0.02338)	(0.13433)	(0.50694)	(0.37523)	(0.02525)
	[0.86803]	[-2.52610]	[-1.61501]	[0.33114]	[-0.07467]
D(IR(-3))	-0.000126	0.224097	1.085365	0.894520	-0.022275
	(0.02096)	(0.12043)	(0.45448)	(0.33640)	(0.02264)
	[-0.00600]	[1.86077]	[2.38815]	[2.65910]	[-0.98397]
D(IR(-4))	-0.017633	0.136617	0.407225	0.148219	-0.032675
	(0.01505)	(0.08647)	(0.32633)	(0.24154)	(0.01625)
	[-1.17183]	[1.57986]	[1.24790]	[0.61363]	[-2.01018]
D(ER(-1))	-0.124662	-1.110717	-3.873074	-2.703214	0.009461
	(0.05744)	(0.33009)	(1.24566)	(0.92202)	(0.06205)
	[-2.17028]	[-3.36489]	[-3.10924]	[-2.93182]	[0.15248]
D(ER(-2))	-0.113602	-1.382443	-4.624450	-2.274296	0.029149
	(0.05617)	(0.32277)	(1.21806)	(0.90159)	(0.06067)
	[-2.02256]	[-4.28300]	[-3.79658]	[-2.52254]	[0.48043]
D(ER(-3))	-0.048795	-1.478153	-5.508909	-2.529160	0.035376
	(0.05759)	(0.33094)	(1.24889)	(0.92441)	(0.06221)
	[-0.84729]	[-4.46648]	[-4.41106]	[-2.73597]	[0.56866]
D(ER(-4))	0.011521	-0.602152	-2.033940	-1.124901	0.036494
	(0.03351)	(0.19258)	(0.72675)	(0.53793)	(0.03620)
	[0.34380]	[-3.12674]	[-2.79868]	[-2.09117]	[1.00812]
D(UNEMPR(-1))	-0.954259	-17.32601	-57.17877	-30.12676	0.465416
	(0.75824)	(4.35734)	(16.4434)	(12.1712)	(0.81906)
	[-1.25852]	[-3.97628]	[-3.47731]	[-2.47526]	[0.56823]

D(UNEMPR(-2))	-0.108822	-16.08112	-52.07160	-28.39798	0.419244
	(0.55533)	(3.19127)	(12.0430)	(8.91403)	(0.59987)
	[-0.19596]	[-5.03909]	[-4.32382]	[-3.18576]	[0.69889]
D(UNEMPR(-3))	0.141969	-1.924929	-2.580068	-4.607142	-0.003667
	(0.29402)	(1.68964)	(6.37620)	(4.71958)	(0.31761)
	[0.48285]	[-1.13926]	[-0.40464]	[-0.97618]	[-0.01155]
D(UNEMPR(-4))	-0.234537	4.848737	12.50295	-0.483627	-0.290556
	(0.26906)	(1.54617)	(5.83480)	(4.31884)	(0.29064)
	[-0.87170]	[3.13597]	[2.14282]	[-0.11198]	[-0.99972]
C	0.837310	8.277173	28.87003	22.30099	0.037502
	(0.37057)	(2.12953)	(8.03623)	(5.94831)	(0.40029)
	[2.25952]	[3.88686]	[3.59248]	[3.74913]	[0.09369]
R-squared	0.915348	0.925631	0.868708	0.814054	0.692847
Adj. R-squared	0.712183	0.747147	0.553606	0.367785	-0.044321
Sum sq. resids	0.771293	25.47108	362.7316	198.7320	0.899989
S.E. equation	0.277722	1.595966	6.022720	4.457937	0.299998
F-statistic	4.505448	5.186056	2.756915	1.824131	0.939876
Log likelihood	17.10027	-44.10127	-90.58336	-80.05351	14.39976
Akaike AIC	0.451413	3.948644	6.604764	6.003058	0.605728
Schwarz SC	1.562376	5.059607	7.715727	7.114021	1.716691
Mean dependent	0.221280	0.116857	-0.151429	2.641429	0.079714
S.D. dependent	0.517668	3.173872	9.014335	5.606624	0.293563

Determinant resid covariance (dof adj.)	0.489880
Determinant resid covariance	0.000933
Log likelihood	-126.2096
Akaike information criterion	15.49769
Schwarz criterion	21.94127
Number of coefficients	145

In order to obtain the P-values from the Vector error correction model (VECM) output table, the model was used to carry out a regression of the first differences of the logarithm of construction output on its four (4) lags and the first differences of explanatory variables also lagged by four (4). The results are displayed in table 4.32.

Table 4.32: Regression Results

Dependent Variable: D(LOG(CO))

Method: Least Squares (Gauss-Newton / Marquardt steps)

Date: 08/15/20 Time: 22:36

Sample (adjusted): 1982 2016

Included observations: 35 after adjustments

D(LOG(CO)) = C(1)*(LOG(CO(-1)) - 1.70478425066*UNEMPR(-1) + 5.16006579703) + C(2)*(CBWR(-1) + 3.15398362602*UNEMPR(-1) - 42.8698396895) + C(3)*(IR(-1) + 2.59685706694*UNEMPR(-1) - 32.2070007271) + C(4)*(ER(-1) - 11.9191124354*UNEMPR(-1) + 36.4942249571) + C(5)*D(LOG(CO(-1))) + C(6)*D(LOG(CO(-2))) + C(7)*D(LOG(CO(-3))) + C(8)*D(LOG(CO(-4))) + C(9)*D(CBWR(-1)) + C(10)*D(CBWR(-2)) + C(11)*D(CBWR(-3)) + C(12)*D(CBWR(-4)) + C(13)*D(IR(-1)) + C(14)*D(IR(-2)) + C(15)*D(IR(-3)) + C(16)*D(IR(-4)) + C(17)*D(ER(-1)) + C(18)*D(ER(-2)) + C(19)*D(ER(-3)) + C(20)*D(ER(-4)) + C(21)*D(UNEMPR(-1)) + C(22)*D(UNEMPR(-2)) + C(23)*D(UNEMPR(-3)) + C(24)*D(UNEMPR(-4)) + C(25)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.860086	0.831909	-2.235925	0.0493
C(2)	-0.090389	0.056617	-1.596486	0.1415
C(3)	0.049816	0.045097	1.104659	0.2952
C(4)	0.135423	0.058290	2.323255	0.0425
C(5)	0.624200	0.586357	1.064539	0.3121
C(6)	0.192010	0.378938	0.506705	0.6233
C(7)	-0.233131	0.178893	-1.303184	0.2217
C(8)	0.160631	0.151190	1.062449	0.3130
C(9)	-0.054510	0.063722	-0.855434	0.4123
C(10)	-0.021744	0.076140	-0.285581	0.7810
C(11)	-0.010520	0.063580	-0.165460	0.8719
C(12)	-0.026610	0.045457	-0.585386	0.5713
C(13)	-0.004017	0.034891	-0.115123	0.9106
C(14)	0.020291	0.023376	0.868029	0.4057
C(15)	-0.000126	0.020957	-0.006005	0.9953
C(16)	-0.017633	0.015048	-1.171826	0.2684

C(17)	-0.124662	0.057440	-2.170275	0.0551
C(18)	-0.113602	0.056167	-2.022560	0.0707
C(19)	-0.048795	0.057589	-0.847290	0.4167
C(20)	0.011521	0.033512	0.343797	0.7381
3C(21)	-0.954259	0.758242	-1.258515	0.2368
C(22)	-0.108822	0.555328	-0.195960	0.8486
C(23)	0.141969	0.294021	0.482854	0.6396
C(24)	-0.234537	0.269056	-0.871701	0.4038
C(25)	0.837310	0.370569	2.259522	0.0474

R-squared	0.915348	Mean dependent var	0.221280
Adjusted R-squared	0.712183	S.D. dependent var	0.517668
S.E. of regression	0.277722	Akaike info criterion	0.451413
Sum squared resid	0.771293	Schwarz criterion	1.562376
Log likelihood	17.10027	Hannan-Quinn criter.	0.834918
F-statistic	4.505448	Durbin-Watson stat	2.018087
Prob(F-statistic)	0.008572		

From the observation of the vector error correction model output table above, C1 is the error correction term or the speed of adjustment towards equilibrium. Therefore, since the coefficient C1is negative and significant, this means that there is a long run causality running from the explanatory variables towards the dependent variable; construction output. The coefficient as observed is -1.86 and the p-value is ($\alpha = 0.0493$) which is lower than ($\alpha = 0.05$).

4.9.5 Wald Tests for Short Run Causality of Explanatory Variables on Construction Output

Presence of short-run causality was assessed by carrying out a Wald test using the relevant coefficients selected from coefficient C1 to C25 as observed from vector error correction regression model output as observed in table 4.31. This was done to establish whether each specific explanatory variable could cause the dependent variable. Wald tests were carried out for this purpose using the coefficients as earlier stated. Using the specific explanatory variable coefficients (C), a null hypothesis was set and eventually tested.

4.9.5.1 Wald Test for CBWR

The null hypothesis for commercial banks weighted interest rates Wald test is:

H_0: C2 = C9 = C10 = C11 = C12 = 0. Therefore, this is tested and the results given in table 4.33.

Table 4.33: Wald Test for CBWR

Wald Test:
Equation: Untitled

Test Statistic	Value	Df	Probability
F-statistic	1.996198	(5, 10)	0.1648
Chi-square	9.980991	5	0.0758

Null Hypothesis: C(2)=C(9)=C(10)=C(11)=C(12)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	-0.090389	0.056617
C(9)	-0.054510	0.063722
C(10)	-0.021744	0.076140
C(11)	-0.010520	0.063580
C(12)	-0.026610	0.045457

It is observed from the above table that there is no short run causality running from CBWR towards construction output (CO). The null hypothesis is accepted since the p-value is 0.076 which is more than $\alpha = 0.05$. These results are displayed in Table 4.33 above.

4.9.5.2 Wald Test for IR

The null hypothesis for inflation rate (IR) Wald Test is given as:

H_0: C3 = C13 = C14 = C15 = C16 = 0. The hypothesis was tested and the results displayed as follows:

Table 4.34: Wald Test for IR

Wald Test:			
Equation: Untitled			
Test Statistic	Value	Df	Probability
F-statistic	**1.736940**	**(5, 10)**	**0.2138**
Chi-square	**8.684701**	**5**	**0.1223**

Null Hypothesis: C(3)=C(13)=C(14)=C(15)=C(16)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	0.049816	0.045097
C(13)	-0.004017	0.034891
C(14)	0.020291	0.023376
C(15)	-0.000126	0.020957
C(16)	-0.017633	0.015048

The p-value = 0.12 which is more than $\alpha = 0.05$ and therefore, there is no short run causality coming from IR to CO. The null hypothesis is accepted.

4.9.5.3 Wald Test for ER

The Kenya shilling per US dollar exchange rate ER was also subjected to Wald test and the following hypothesis tested.

H_0: C4 = C17 = C18 = C19 = C20 = 0

The results of this test are given in table 4.35

Table 4.35: Wald Test for ER

Wald Test:			
Equation: Untitled			
Test Statistic	**Value**	**Df**	**Probability**
F-statistic	7.748970	(5, 10)	0.0032
Chi-square	38.74485	5	0.0000

Null Hypothesis: C(4)=C(17)=C(18)=C(19)=C(20)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	0.135423	0.058290
C(17)	-0.124662	0.057440
C(18)	-0.113602	0.056167
C(19)	-0.048795	0.057589
C(20)	0.011521	0.033512

These results as observed from the above table indicate that there is a short run causality running from exchange rate (ER) to construction output. The p-value = 0 (zero) meaning the null hypothesis is rejected.

4.9.5.4 Wald Test for UNEMPR

The Wald test was as well conducted on unemployment rate (UNEMPR) to establish its short run effect on the construction output. The results are displayed in the table 4.36. The null hypothesis for this test was: H_0: C21=C22=C23=C24=0

Table 4.36: Wald Test for UNEMPR

Wald Test:			
Equation: Untitled			
Test Statistic	**Value**	**Df**	**Probability**
F-statistic	1.371994	(4, 10)	0.3110
Chi-square	5.487978	4	0.2408

Null Hypothesis: C(21)=C(22)=C(23)=C(24)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(21)	-0.954259	0.758242
C(22)	-0.108822	0.555328
C(23)	0.141969	0.294021
C(24)	-0.234537	0.269056

From this table, it is observed that the p-value = 0.24, implying that the null hypothesis is accepted and therefore, there is no short run effect of this variable on construction output in Kenya.

From the results obtained from the Wald tests, it can be concluded that there is a long run effect of the four (4) explanatory variables on construction output. It is however observed that there is no short run effect of these explanatory variables on construction output in Kenya.

4.9.6 The Model Diagnostic Checking

From earlier analysis of the VECM, it was observed that all the features of the model are within the acceptable limits. Some of these include the R^2 value which was observed to be 0.915, Durbin Watson value of two (2.0) and probability of F-statistic of 0.008. These are indications that the vector error correction model fitted well to the time series data.

As a way of confirming that the model works perfectly well, a number of checks were carried out on the developed restricted vector auto-regression model. This was mainly to ensure the model is sound and free from any error that may lead to spurious restricted auto-regression. Specifically, the diagnostic checks which were done included serial correlation, heteroscedasticity and test of normality.

4.9.7 Serial Correlation Test

The Breusch-Godfrey serial correlation test was used for this purpose and the results displayed in the table 4.37 overleaf.

Table: 4.37: Serial Correlation Test Results

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.211027	Prob. F(2,8)	0.8141
Obs*R-squared	1.753957	Prob. Chi-Square(2)	0.4160

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 08/16/20 Time: 17:15
Sample: 1982 2016
Included observations: 35

These results indicate a p-value of 0.416 which means the model has no serial correlation. The null hypothesis that the residuals have serial correlation is rejected.

4.9.8 Heteroscedasticity Test

Breusch-Pagan -Godfrey method of testing heteroscedasticity in the residuals was used. Results are displayed in the table below.

Table 4.38: Heteroscedasticity Test Results

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.361420	Prob. F(25,9)	0.9786
Obs*R-squared	17.53446	Prob. Chi-Square(25)	0.8615
Scaled explained SS	1.678210	Prob. Chi-Square(25)	1.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 08/16/20 Time: 20:13
Sample: 1982 2016
Included observations: 35

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.031790	0.830455	0.038281	0.9703
CO(-1)	-1.03E-06	1.13E-06	-0.904475	0.3893
UNEMPR(-1)	0.008742	0.070990	0.123140	0.9047
CBWR(-1)	0.005219	0.009218	0.566211	0.5851
IR(-1)	-0.003583	0.005447	-0.657766	0.5272
ER(-1)	0.000150	0.005961	0.025208	0.9804
CO(-2)	2.52E-07	1.30E-06	0.193709	0.8507
CO(-3)	7.62E-07	9.18E-07	0.830213	0.4279
CO(-4)	-1.21E-06	1.33E-06	-0.913689	0.3847
CO(-5)	-1.41E-06	2.11E-06	-0.666011	0.5221
CBWR(-2)	-0.007367	0.008371	-0.880017	0.4017
CBWR(-3)	0.004705	0.007466	0.630228	0.5442
CBWR(-4)	0.003224	0.010182	0.316600	0.7588
CBWR(-5)	-0.011504	0.011716	-0.981913	0.3518
IR(-2)	-0.000415	0.003477	-0.119329	0.9076
IR(-3)	-0.002571	0.002720	-0.945356	0.3692
IR(-4)	-0.000576	0.002478	-0.232290	0.8215
IR(-5)	-0.000435	0.001907	-0.228265	0.8245
ER(-2)	0.003442	0.004594	0.749344	0.4728
ER(-3)	0.002418	0.005431	0.445173	0.6667
ER(-4)	-0.007196	0.005761	-1.249059	0.2432
ER(-5)	0.003365	0.007625	0.441368	0.6694
UNEMPR(-2)	-0.047700	0.081478	-0.585439	0.5726

UNEMPR(-3)	-0.043271	0.059730	-0.724441	0.4872
UNEMPR(-4)	0.050902	0.073804	0.689692	0.5078
UNEMPR(-5)	0.049519	0.089874	0.550982	0.5951

R-squared	0.500985	Mean dependent var	0.022037
Adjusted R-squared	-0.885170	S.D. dependent var	0.034238
S.E. of regression	0.047009	Akaike info criterion	-3.149364
Sum squared resid	0.019889	Schwarz criterion	-1.993963
Log likelihood	81.11387	Hannan-Quinn criter.	-2.750520
F-statistic	0.361420	Durbin-Watson stat	1.620798
Prob(F-statistic)	0.978607		

The null hypothesis that there is heteroscedasticity in the residuals is rejected. The p-value is 0.86 which is higher than (α=0.05). Therefore, the null hypothesis cannot be accepted.

4.9.9 Test of Normality

Normality test was done and its results are as shown in figure 4.13

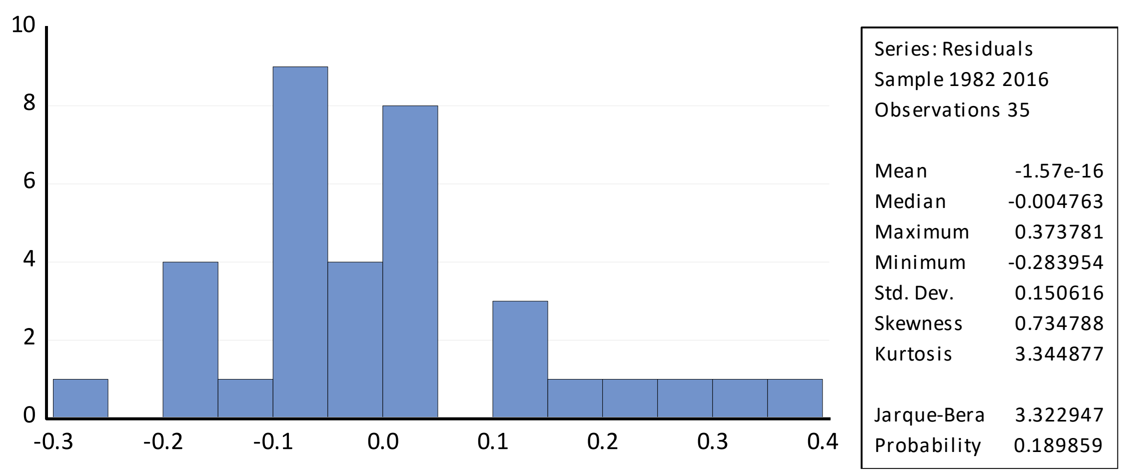


Figure 4.13: Normality Test Results

The observed P-value is 0.18 which is more than (α = 0.05). This means the null hypothesis that the residuals are normally distributed cannot be rejected, rather it is accepted. These results are observed in figure 4.13 above.

4.10 ARIMA Modeling of Construction Output

An Autoregressive Integrated Moving Average (ARIMA) model for construction output was carried out with the aid of the following model:

$$CO_t = \theta + \alpha_1 CO_{t-1} + \alpha_2 CO_{t-2} + \ldots\ldots + \alpha_p CO_{t-p} + \beta_0 \mu_t + \beta_1 \mu_{t-1} + \beta_2 \mu_{t-2} + \ldots\ldots + \beta_q \mu_{t-q} \quad (31)$$

Where:

θ = represents a constant term

p = the number of autoregressive terms

q = the number of moving average terms,

μ_t = unautocorrelated random error term with zero mean and constant variance (σ^2).

Construction output in Kenya was regressed on its own lagged values and error terms and the results displayed in the following tables.

Table 4.39: Correlogram of Differenced Logarithm of Construction Output

Date: 07/29/20 Time: 08:53
Sample: 1977 2016
Included observations: 39

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.094	-0.094	0.3706	0.543
		2	0.026	0.018	0.4008	0.818
		3	-0.054	-0.050	0.5296	0.912
		4	0.299	0.292	4.6026	0.331
		5	-0.328	-0.306	9.6505	0.086
		6	0.173	0.170	11.097	0.085
		7	-0.009	0.012	11.101	0.134
		8	-0.024	-0.155	11.132	0.194
		9	-0.152	0.064	12.357	0.194
		10	0.238	0.058	15.489	0.115
		11	-0.165	-0.120	17.042	0.107
		12	-0.120	-0.098	17.898	0.119
		13	-0.117	-0.151	18.739	0.131
		14	0.019	-0.107	18.763	0.174
		15	-0.106	0.086	19.505	0.192
		16	0.035	-0.052	19.592	0.239

From table 4.39, it does not appear as if there is any systematic information in the construction output time series data that can help in explaining its behavior. The autocorrelation as observed from this correlogram lies within its boundaries which means even the fourth and the fifth order autocorrelations are not significant. For this reason, it is clear that it does not have any theoretical resemblance of an autoregressive (AR) process nor a moving average (MA) process.

It is further drawn from model selection criteria; Akaike Information Critria,(AIC) as shown on table 4.40 and figure 4.14 that numerous regressions were run of different combinations of AR and MA and tests of their explanatory powers carried out. This position is also reaffirmed by forecast comparison graph which appears in figure 4.15. In the final analysis, ARIMA (0, 1, 0) model which yielded some relevant results was modeled. It is therefore this ARIMA (0, 1, 0,) process which gives a comprehensive description of the annual variations of construction output in Kenya between 1977 and

2019. This carries the implication that ARIMA (0, 1, 0) process has no AR and MA terms and that level construction output data are integrated of order one. These regression results of the ARIMA (0, 1, 0) are presented in table 4.40.

Table 4.40: Model Selection Criteria Table Results

Model Selection Criteria Table
Dependent Variable: DLOG(CO)
Date: 08/04/20 Time: 15:14
Sample: 1977 2016
Included observations: 39

Model	LogL	AIC*	BIC	HQ
(0,0)(0,0)	-27.079340	1.491248	1.576559	1.521857
(1,1)(0,0)	-25.774731	1.526909	1.697531	1.588127
(1,0)(0,0)	-26.910710	1.533883	1.661849	1.579796
(0,1)(0,0)	-26.916896	1.534200	1.662166	1.580113
(4,2)(0,0)	-22.188398	1.548123	1.889366	1.670558
(3,2)(0,0)	-23.335642	1.555674	1.854262	1.662805
(0,4)(0,0)	-24.485667	1.563368	1.819300	1.655194
(1,3)(0,0)	-24.520258	1.565141	1.821074	1.656968
(4,1)(0,0)	-23.618845	1.570197	1.868785	1.677328
(1,4)(0,0)	-23.624602	1.570492	1.869080	1.677623
(1,2)(0,0)	-25.656015	1.572103	1.785380	1.648625
(2,1)(0,0)	-25.707113	1.574724	1.788001	1.651246
(2,2)(0,0)	-24.848803	1.581990	1.837922	1.673816
(3,4)(0,0)	-21.903387	1.584789	1.968688	1.722529
(2,0)(0,0)	-26.904921	1.584868	1.755489	1.646085
(0,2)(0,0)	-26.909873	1.585122	1.755743	1.646339
(2,3)(0,0)	-23.984481	1.588948	1.887536	1.696079
(3,1)(0,0)	-25.133612	1.596596	1.852528	1.688422
(2,4)(0,0)	-23.209481	1.600486	1.941730	1.722921
(4,0)(0,0)	-25.268700	1.603523	1.859456	1.695349
(3,0)(0,0)	-26.858699	1.633779	1.847057	1.710301
(0,3)(0,0)	-26.909847	1.636402	1.849680	1.712924
(4,4)(0,0)	-22.000629	1.641058	2.067612	1.794102
(4,3)(0,0)	-23.050255	1.643603	2.027502	1.781342
(3,3)(0,0)	-24.140351	1.648223	1.989467	1.770658

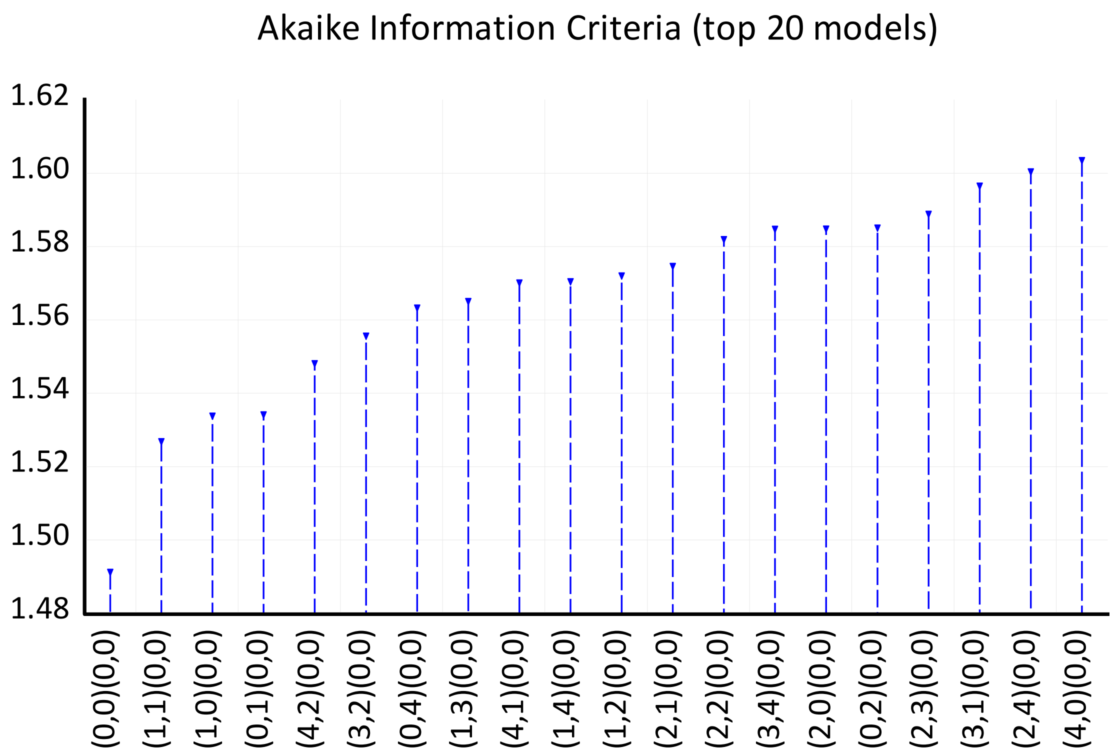


Figure 4.14: Akaike Information Criteria Results

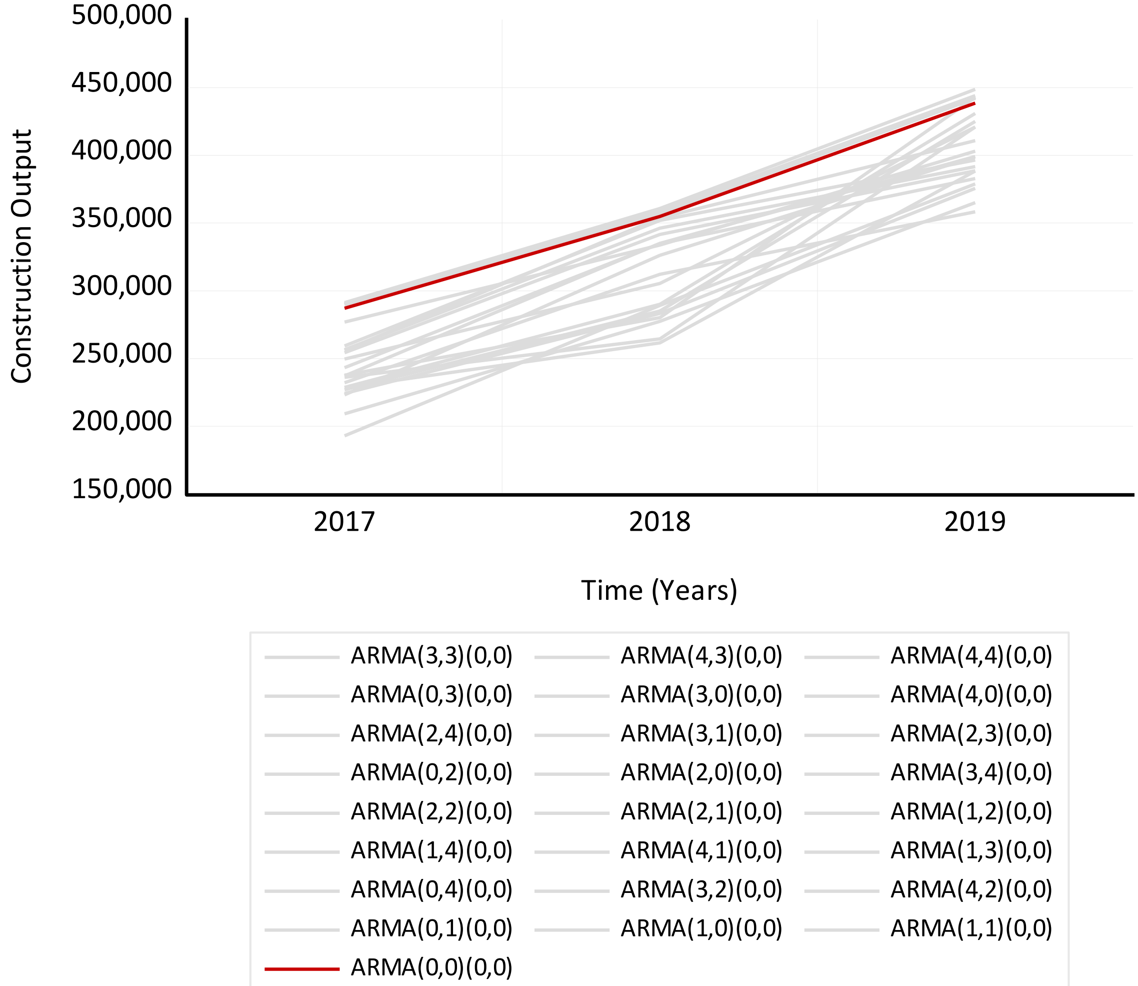


Figure 4.15: Forecast Comparison Graph

Table 4.41: ARIMA Model of Differenced Logarithm of Construction Output

Dependent Variable: Difference of Logarithm of Construction output				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.211950	0.078600	2.696582	0.0104
R-squared	0.000000	Mean dependent var		0.211950
Adjusted R-squared	0.000000	S.D. dependent var		0.490854
S.E. of regression	0.490854	Akaike info criterion		1.439966
Sum squared resid	9.155627	Schwarz criterion		1.482622

og likelihood	-27.07934	Hannan-Quinn criter.	1.455271
Durbin-Watson stat	2.185191		

The R^2 value observed for this ARIMA model is zero though it is quite important to note that this is due to the absence of AR and MA values in the model. As observed from the regression output table above, it is as well observed that the Durbin Watson (DW) value indicates that residuals do not have serial correlations. Further, it is however notable that the constant term is insignificant which implies that all construction output variations in Kenya are well explained in this model as per the analyzed data of 1977 to 2019. This state of things is demystified by the correlogram of residuals as indicated in table 4.42 hereafter. From this table, it is observable that all the autocorrelations in different lag-lengths are all kept within the required limit.

Table 4.42: Correlogram of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.087	-0.087	0.3441	0.557
		2	0.031	0.024	0.3895	0.823
		3	-0.049	-0.045	0.5029	0.918
		4	0.302	0.297	4.9430	0.293
		5	-0.333	-0.315	10.486	0.063
		6	0.164	0.163	11.867	0.065
		7	-0.016	0.002	11.880	0.105
		8	-0.017	-0.148	11.895	0.156
		9	-0.144	0.081	13.049	0.160
		10	0.253	0.074	16.743	0.080
		11	-0.147	-0.097	18.032	0.081
		12	-0.104	-0.085	18.704	0.096
		13	-0.113	-0.145	19.520	0.108
		14	0.023	-0.103	19.554	0.145
		15	-0.135	0.051	20.795	0.144
		16	0.005	-0.083	20.796	0.186
		17	-0.082	-0.086	21.297	0.213
		18	-0.062	-0.052	21.596	0.250
		19	-0.065	-0.075	21.936	0.287
		20	-0.001	-0.073	21.937	0.344

Based on regression results displayed in table 4.40, the following is an ARIMA expression that describes Kenya's construction output: -

$DLog(CO_t) = 0.21$ …………………………………………………… (32)

Where,

$Dlog(COt) = Log(CO_t) – Log(CO_{t-1})$ (the first difference of logarithm of construction output)

The ARIMA equation can now be expressed in terms of construction output level and given as hereafter: -

$DLog(CO_t) = 0.21$ is now expanded to

$Log(CO_t) – Log(CO_{t-1}) = 0.2$

Reorganization of the equation above results in the following equation: -

$Log(CO_t) = 0.21 + Log(CO_{t-1})$ ………………………………………………. (33)

This equation implies that Kenya's construction output at any one given year is influenced by its level in the previous year.

4.10.1 ARIMA Forecasting

The forecasting was carried out to predict the levels of construction output in the next three years. That is from 2017 to 2019. The forecasting results are shown in table 4.43 and figure 4.16

Table 4.43: Automatic ARIMA Forecasting Results

Automatic ARIMA Forecasting
Selected dependent variable: DLOG(CO)
Date: 08/04/20 Time: 15:14
Sample: 1977 2016
Included observations: 39
Forecast length: 3
Number of estimated ARMA models: 25
Number of non-converged estimations: 0
Selected ARMA model: (0,0)(0,0)
AIC value: 1.49124819017

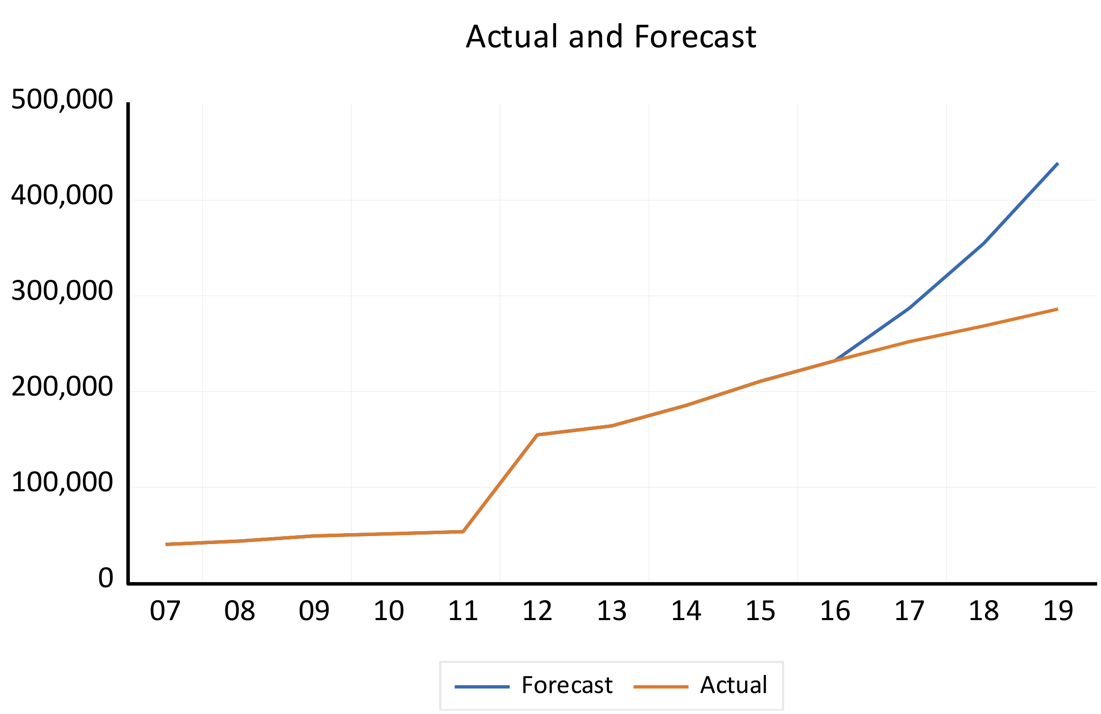


Figure 4.16: ARIMA Forecasting Graph

4.10.2 Forecasting Evaluation

Forecasting accuracy for the three (3) year out-of-sample forecasts were evaluated and the results obtained are given in table 4.44 and figure 4.17.

Table 4.44: Forecasting Evaluation Results

Forecast Evaluation						
Sample: 2017 2019						
Included observations: 3						
Evaluation sample: 2017 2019						
Training sample: 2000 2016						
Number of forecasts: 6						
Combination tests						
Null hypothesis: Forecast includes all information contained in others						
Forecast	**F-stat**	**F-prob**				
CO	NA	NA				
Evaluation statistics						
Forecast	**RMSE**	**MAE**	**MAPE**	**SMAPE**	**Theil U1**	**Theil U2**
CO	103098.5	91235.61	23.75538	27.57530	0.162413	1.569534
Simple mean	103098.5	91235.61	23.75538	27.57530	0.162413	1.569534
Simple median	103098.5	91235.61	23.75538	27.57530	0.162413	1.569534
Least-squares	103098.5	91235.61	23.75538	27.57530	0.162413	1.569534
MSE ranks	103098.5	91235.61	23.75538	27.57530	0.162413	1.569534

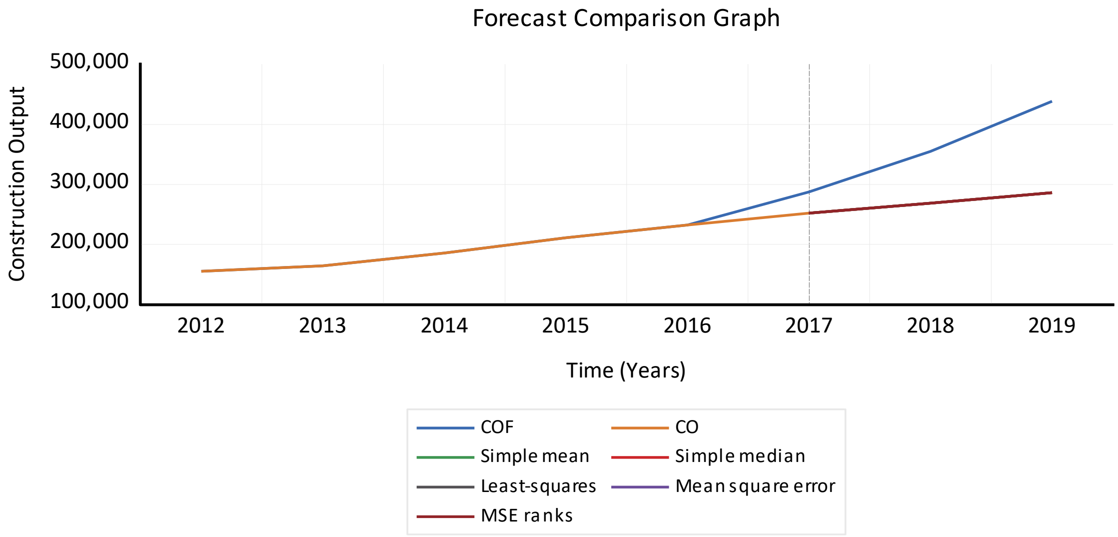


Figure 4.17: Forecast Comparison Graph

The results observed in the above table 4.44 and figure 4.17 appear impressive since the accuracy measurement parameters indicate appreciable figures. The figures as presented in the table and forecast comparison graph show that Root Mean Square Error (RMSE) is 103098.5 and the Mean Absolute Percentage Error (MAPE) is 23.8%. These error levels imply that the ARIMA model developed in this research carry a fairly good predictive power and has explained the construction output variations in Kenya for the period in question; 1977 to 2019 to a fairly good degree of accuracy.

The fitted values of the ARIMA models are given in figure 4.18. They were estimated from the ARIMA Model during forecasting. The difference between the actual observations and the fitted values are the residuals as observed in this ARIMA model. Therefore, the fitted values and the actual observations correspond each other as indicated in fig.4.18.

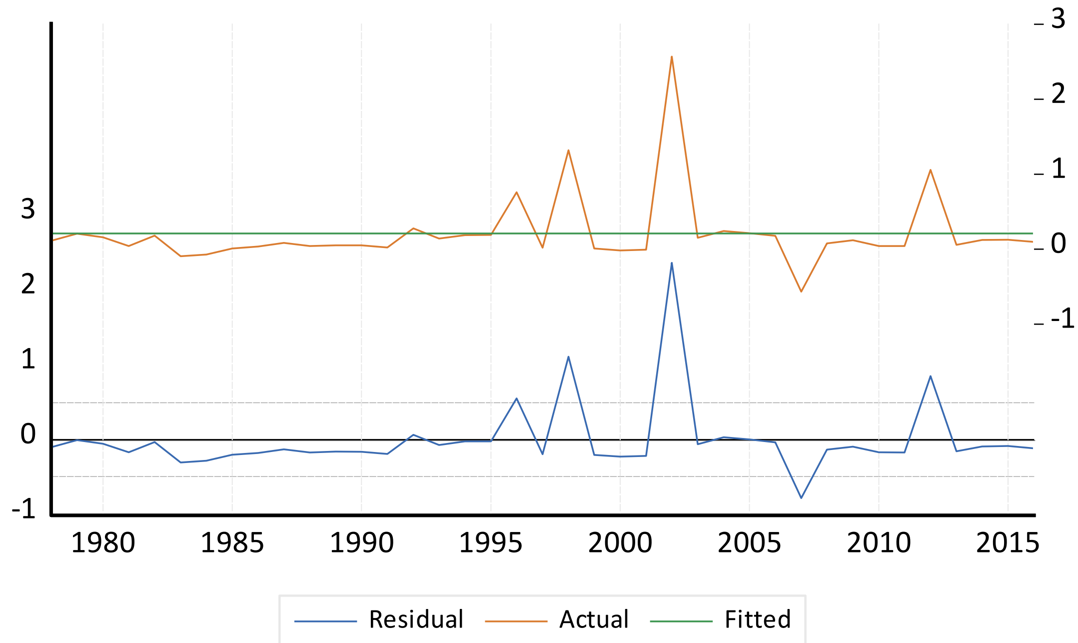


Figure 4.18: ARIMA Fitted Values and Residuals Graph

4.11 Discussion of Findings

This research arrived at a number of findings which are insightful as regards to the influence of macroeconomic factors on annual construction output levels in Kenya. The findings were reached through various data analysis methods which included graphical, stationarity tests, correlation analysis, multiple regression analysis, dynamic regression analysis and autoregressive integrated moving average (ARIMA). It should also be noted that time series data analysis procedures were keenly followed to ensure reliable results were obtained.

It was found in this research that construction output levels are influenced by macroeconomic factors in Kenya. The macro-economic factors are unemployment rate in Kenya, population growth rate in Kenya, interest rates in Kenya, inflation rate in Kenya, and exchange rate (Kenya shilling to US Dollar). These factors influence construction output levels as far back as twelve years. It was also found that these factors were not thoroughly investigated in this country even though there is notmuch earlier research work done in this area. In fact, this work comes second after Kivaa, (2008) to apply time series data analysis in the country. Elsewhere, most of the work done is not very closely related to this work. For example, Hua, (1996) looked at residential construction demand forecasting using economic indicators in Singapore. The dependent variable in this work was GFCF for residential buildings in Singapore.

In the perspective of research results, Hua (1996) produced the best results as compared to this work. The R^2 value of his work is 0.9685 even though the residuals were found to be highly auto correlated. He obtained such a high R^2 value due to this auto correlation and the use of residential building construction GFCF which is just a small share of the construction industry in Singapore. Moreover, this research produced better results as compared to Kivaa, (2008). This is attributable to the use of construction GDP as a proxy for construction output as opposed to gross fixed capital formation (GFCF) which was used in Kivaa, (2008). Therefore, it can be observed that the multiple regression and autoregressive integrated moving average (ARIMA) in this research produced an R^2 value of 0.48 and a prediction error of 23.8% while Kivaa, (2008) gave 0.37 and 40% respectively. However, there is a difference between this work and Kivaa, (2008) in that dynamic regression was done in this research after realizing the economic variables are cointegrated which is a new insight.

In this research, gross domestic product (GDP) was not included as a variable. The reason behind this being that the dependent variable (construction output) in this research is Kenya's construction GDP which is a fraction of the GDP in the country. It was therefore found illogical to regress Gross Domestic Product (GDP) on construction GDP in Kenya which would have yielded spurious results.

4.12 Conclusion

In this chapter, time series method of data analysis has been applied to carry out data analysis for the six (6) economic variables in this research. Each step in the econometric method was followed to ensure accurate and reliable results are obtained. These very important steps included graphical analysis, stationarity considerations, correlation analysis, multiple regression of current variables, multiple regression of lagged variables, cointegration considerations, multicollinearity tests and finally ARIMA regression analysis. Therefore, the results produced by the whole process reflect the true economic situation in the construction industry of Kenya.

Graphical analysis which is traditionally the first step in time series analysis was performed by graphing all the variables. This assisted in getting a glimpse of the components of the time series in terms of their identification (Gujarati & Porter, 2009) and (Wooldridge, 2013). They included trend component, cyclical component, seasonal component and error component. It was also noticed from this analysis that construction industry appeared to grow with very low rate alongside many fluctuations for the whole period under consideration.

The data was subjected to stationarity test as the second step after graphical analysis. It was found to be nonstationary as it is usually the norm with most economic time series data. However, after transforming it, the first differences were stationary for construction output (CO), commercial banks weighted interest rate (CBWR), inflation rate (IR), US dollar to Kenya shilling exchange rate (ER) and unemployment rate (UNEMPR) but in the case of population growth rate (POPGR), the second differences were found to be stationary. This test and eventual transformation paved way for correlation analysis.

The correlation analysis did not produce very impressive results. The coefficients of correlation (r) were not very high but they gave at least an indication of the direction towards which they pull construction output in the country. In addition, the results from this analysis showed that the time series variables' data did not suffer from multicollinearity.

Similar to correlation analysis, multiple regression of construction output on the current macro-economic variables did not produce significant results. However, the results improved substantially for multiple regression of construction output on lagged macro-economic variables. The R^2 value increased fourfold.

Nonlinear regression of construction output on macro-economic variables did not show a strong link with the five (5) explanatory variables. Both the quadratic and the exponential regression models showed a weak nonlinear relationship between the construction output and macro-economic variables. As observed from the regression results, these variables displayed insignificant regression coefficients except a few.

The results that have been obtained from earlier stages of the data analysis portrayed that the variables could be cointegrated. This prompted the researcher to carry out Johansen cointegration test which confirmed the situation. To address this, a vector error correction model (VECM) was developed. Using the model, which is a restricted vector autoregressive (VAR) model, very impressive results were obtained. Tests to confirm soundness of the model in relation to all the variables' data included in the model showed absence of serial correlation, heteroscedasticity and that the residuals were normally distributed. This meant that the data fitted very well in the VECM.

Autoregressive integrated moving average (ARIMA) model (0,1,0) was identified and gave satisfactory results. Once tested for forecasting accuracy, it was observed that it could fairly do good forecasts for up to three (3) years. Therefore, the ARIMA model can be used for forecasting construction output in Kenya with minimal forecasting errors.

CHAPTER FIVE

CONCLUSIONS AND IMPLICATIONS

5.1 Introduction

In the previous chapters, the foundation for this research was laid in a stepwise manner. For example, in chapter one, the problem addressed in this research was introduced and the pathway towards the problem investigation highlighted. The second chapter discussed the reviewed literature which is related to construction industry output and the macro-economic factors that affect it. In the third chapter, the route from data collection methods up to the data analysis methods and procedures are carefully elaborated for purposes of ensuring that proper research procedures are adhered to in this study.

Towards the conclusion of the second chapter of this research thesis, knowledge gap is identified that the macro-economic factors have not been empirically incorporated in policy design for enhanced construction activity in Kenya. In chapter Four, the study findings are presented indicating how each of the five objectives set out in the first chapter were achieved through the analysis of the data and interpretation. Development of time series regression models in this research was very key and the models developed proved to be very insightful as regards to construction output levels and the macro-economic factors affecting it in Kenya.

This chapter presents conclusions regarding the study aim and objectives of the study based on the data analysis findings. Theory and policy implications of the findings to the construction industry of Kenya are also highlighted and further research areas identified.

5.2 Conclusions about the Research Aim and Objectives

The research objectives in this study were all achieved and hence its research aim was consequently attained. This research aimed at investigating the influence that macro-economic factors have on construction output levels in Kenya, for the purpose of enhancing accuracy in the explanation of changes in the output, and enhancement of policy design and implementation for the growth and development of the construction industry. The specific objectives were:

1. To analyze the trends of construction output and the macro - economic factors that affect it in Kenya.
2. To find out the relationship between construction output and the macroeconomic factors that have been influencing it in Kenya over a period of forty-three (43) years – from 1977 to 2019.
3. To establish the way past levels of construction output have been influencing present levels over the period of forty-three (43) years.

From review of related literature, the macro-economic factors affecting annual construction output levels in diverse ways were found to be:

1. Unemployment rate in Kenya,
2. Population growth rate in Kenya,
3. Interest rates in Kenya,
4. Inflation rate in Kenya, and finally
5. Exchange rate (Kenya shilling to US Dollar)

The five (5) factors were considered in the data analysis and hypothesis testing and the following are the conclusions made in respect of each of the objectives: -

5.2.1 Trend Analysis of Construction Output and the Explanatory Variables

All the variables were plotted on graphs and examined for presence of time series components and heteroscedasticity. This was essentially done to ensure conformity with the principles of time series analysis as indicated in Gujarati, (2009) and Wooldridge, (2013). All the variables had trend component except inflation rate (IR) and commercial banks weighted interest rates (CBWR) which appeared to present some form of cyclical component. Trend for construction output (CO) and US dollar to Kenya Shilling exchange rate (ER) were going upward while population growth rate (POPGR) displayed a downward trend. The upward trend with fluctuations for construction output (CO) was an indication of slow growth in the construction industry for the period under consideration in this research. Heteroscedasticity was only identifiable in construction output (CO) and the problem was addressed through logarithmic transformation.

5.2.2 Stationarity Analysis of Construction Output and the Explanatory Variables

Prior to further analysis, stationarity test process was taken as a serious and crucial process. The key factor for this being that, the reliability and accuracy of the results obtained in this research were very much dependent on the stationarity of the time series data as explained in Gujarati & Porter, (2009) and Wooldridge, (2013). They explain that non-stationarity of the time series data may lead to spurious regression. In order to avoid this situation, the time series data for all the economic variables were thoroughly investigated for this condition.

It was observed that all the graphs had a trend component. According to Gujarati, (2009) and Wooldridge, (2013), this is an implication of nonstationarity of the variables' time series data and it is commonly observed in most economic time series data. Therefore, after differencing, it was realized that all the time series data for all the variables except population growth rate were achieving stationarity in their first differences. The population growth rate achieved stationarity after taking its second differences. A graph with no trend is an indication of stationarity for a specific variable.

Autocorrelation Functions (ACF) and the correlogram test also showed similar results. Each variable was subjected to this test and results displayed on tables. It was noticed that apart from one variable; population growth rate, which had its second differences stationary, the rest of the variables had their first differences stationary.

Augmented Dickey-Fuller (ADF) unit root test, which is considered to be a very reliable stationarity test, confirmed presence of a unit root in all the time series data. It is said to be a powerful tool for dealing with the presence of a unit root in a time series data which is a condition of unstationarity. The null hypothesis was that a specific variable's first/second differences had a unit root. This null hypothesis was rejected in all the variables which were a confirmation of stationarity. It was further confirmed by their P-values which were zero in all the cases. It was therefore concluded that:

1) The first and second differences of the time series data were stationary
2) The time series data in this research are integrated of order (1) and (2)
3) Further analysis could be conducted.

5.2.3 Correlations between Construction Output and the Macro-Economic Factors

This objective is addressed in section 4.5 of this research where the results of correlation analysis are presented. It was observed that the first differences of the logarithm of construction output are directly correlated to three (3) variables of macro-economic factors. They include the first differences of unemployment rate, commercial banks weighted interest rate and the second differences of population growth rate. Their correlation coefficients (r) are 0.27, 0.08 and 0.16 respectively. The construction output is as well inversely correlated to two (2) stationary macro-economic variables. They include the first differences of inflation rate and US dollar to Kenya shilling exchange rate. Their correlation coefficients (r) are -0.06 and -0.08 respectively. It is however noted that the correlation coefficients (r) are very low. This implies that the relationship between the construction output and the macro-economic variables are not very strong.

5.2.4 Construction Output Time Series Models

A number of annual construction output models in Kenya have been developed in this research. The models include multiple regression model on current explanatory variables, multiple regression model on lagged values of explanatory variables, nonlinear regression models; quadratic and exponential regression models, vector autoregressive (VAR) model, vector error correction model (VECM) and autoregressive integrated moving average (ARIMA) model. In a nutshell, there is a significant influence of past levels of construction output on the current output of construction industry in Kenya. It has also been established that, construction output in Kenya is strongly impacted by macro-economic factors. It is observed that the models developed in this research display higher explanatory powers as compared to other prior studies carried out on construction industry.

As observed from previous chapters in this report, time series multiple regression modeling of construction activity in different parts of the world are highlighted. They include Flaherty & Lombardo, (2000), Akintoye & Skitmore, (1991 & 1994) Kivaa, (2008) and Hua, (1996). Examples of past ARIMA model are Kivaa, (2008), Notman *et al*, (1998) and Flaherty & Lombardo, (2000). From these past studies, it is only one study which obtained a higher coefficient of determination (R^2 value) than the one obtained in this research. The difference between the R^2 value in this research and the past studies is only 0.065.

The main reason for this difference is due to the use of nonstationary time series data in the past study which may have led to spurious regression (Gujarati & Porter, 2009). In this research the results are reliable because of the measures which were taken into account to ensure accurate results are obtained. These measures included stationarity tests and transformations, autocorrelation tests, heteroscedasticity tests, multicollinearity tests and tests of normality (Gujarati & Porter, 2009) and (Wooldridge, 2013). For this reason, the results obtained in this research are accurate and reliable.

5.3 Conclusions about the Research Problem

Conclusions drawn in this research based on the research problem; that there exists a problem in the management of construction industry in Kenya at macro level. This is observed to manifest itself in three dimensions; demand estimation, supply targeting and control of construction output in the country. Therefore, this inefficiency in the management of construction industry has seen a number of policies regarding construction output in Kenya failing. Further, the relationship between construction output and macro-economic factors in Kenya is not clear – thoroughly explored in this study, is fundamentally due to failure of clear understanding of the effect of macro-economic factors on construction output in Kenya. In practice, that relationship is normally expressed in qualitative and heuristic terms as seen in Kivaa, (2008) and Odunga, (2017) which are often inaccurate. Therefore, a change in the behavior of the construction industry in terms of growth; steady growth without fluctuations in Kenya shall definitely be observed once the impacts of the macro-economic factors are accounted for in the policy formulation for the industry in Kenya.

Construction industry significantly contributes to the gross domestic product (GDP) of Kenya. Ideally, it should be able to meet the construction demand for the country, by supplying all the constructed facilities required in the country. While performing this key task, it should create employment as it maintains a steady growth. This important function of the industry calls for policy refinement or/formulation for purposes of enabling the industry to perform its role and boosting growth of the industry's production capacity. One way of achieving this is to first factor in the impact of the five macro-economic factors on the construction activity in the country. This shall create an enabling environment for the developers to initiate more construction projects due to access of cheap construction project funds.

The hypothesis in this research that construction output levels are impacted by macro-economic factors in Kenya is not rejected. Conclusions based on this hypothesis are that:

i) Construction output in Kenya is impacted by its own past values
ii) The past values of macro-economic factors namely commercial banks weighted interest rates, inflation rate, US dollar to Kenya shilling exchange rate, unemployment rate and population growth rate influence construction output in Kenya.

In addition to the above impacts on construction output in Kenya, there are several insights obtainable from this research in relation to the research problem. The insights are:

i) The response of construction output to the macro-economic factors is not instantaneous. The effect is felt a few years later.
ii) Demand for constructed facilities can be predicted/forecasted for up to three (3) years in the future Using ARIMA model developed in this research.
iii) Construction output and the macro-economic factors are co-integrated
iv) Logarithms of construction output in Kenya are normally distributed
v) Restricted vector auto-regressive (VAR) model or error correction model (VECM) gives better and more comprehensive understanding of the construction industry's behavior in Kenya than multiple regression models.

Firstly, it is because the stochastic process of construction output time series data could not be properly captured by the multiple regression modeling. This has even been observed in the previous studies such as Kivaa, (2008) where the modeling of construction activities gave a low coefficient of determination (R^2 values). These low R^2 values implied low explanatory power of the models. Also, in this study, the R^2 values of the developed multiple regression models are 0.13 and 0.48 respectively. This is an indication that, even though the R^2 value has increased after regression of construction output on the lagged values of macro-economic factors, the model has only explained construction output by a bare 48%. A clear pointer of the low explanatory powers of multiple regression models. It is also worth noting that low R^2 value is also an indication that there may be other important and relevant factors that have not been included in this research.

Lastly, the economic time series variables are co-integrated. The implication of this scenario in time series modeling is that all the time series economic variables in this study have similar trend component. Therefore, this could only be captured properly in a restricted vector auto-regressive (VAR) model or a vector error correction model

(VECM) where a cointegrating term was included to correct the co-integration problem among the variables. In this form of modeling, which is also referred to as dynamic modeling, portrays the time path of construction output in relation to its past values. It included the lagged values of construction output on the right-hand side of the model alongside macro-economic factors. The variables were all integrated of order one (I/1) as is the requirement of a restricted vector auto-regressive (VAR) model. The restricted vector autoregressive (VAR) modeling produced better results as compared to multiple regression models which implied that VAR model is the most appropriate form of modeling for construction output and macro-economic factors in Kenya.

Even though the restricted VAR model produced encouraging results in this research, it was found to be limited in its application. The model can only be applied to variables that are known to be co-integrated and as well integrated of order one (I/1). In this respect, variables that are integrated of higher order cannot be included in a VAR model. This led to one of the substantive variables in this research being left out since it was integrated of order two (I/2). The reason for using variables which are integrated of order one (I/1) in a VAR model is because the variables are transformed into their first differences automatically during regression.

Based on the conclusions drown about the research problem and objectives, it is clearly observable that this research emerges with new contributions to the construction economics body of knowledge in a number of dimensions. They include: (i) the research performs multiple regression, nonlinear regression, dynamic and ARIMA modeling of construction output in Kenya. Based on the literature reviewed, it is only in Kivaa, (2008) where multiple regression and ARIMA modeling of construction output in Kenya has been modeled. The rest have not been carried out in the past works reviewed. (ii) the research has performed restricted VAR which is not a commonly adopted form of modeling construction output. (iii) nonlinear regression methods used in this research for modeling construction output in Kenya has not been adopted in any of the past works reviewed. When a body of knowledge is stretched just a little by way of relative utilization of new ways in a specific area, applying it for the first time where before it has not been used, interpreting and synthesizing differently than before, this implies distinctive contribution to knowledge (Perry, 2002). Therefore, this research is making distinctive contribution to factual knowledge about Kenya's construction industry and also of theory regarding construction management and economics in general.

5.4 Implications of the Findings for Theory of construction Economics

Putting it in a nutshell, the development of the restricted vector auto-regressive model (VAR) for construction output and the macro-economic factors that influence it is a major break-through. It implies that construction output trend component can now be initially studied to understand the construction industry's growth behavior and evolution prior to policy formulation and implementation. This shall help in getting to understand the policy impact on the construction industry prior to its implementation and provide guidance on the direction the intended policy will take the industry. This simply means that the restricted VAR model is actually going to be a major decision-making tool for policy makers in relation to construction industry in Kenya.

On account of the observations made in this research, there are various implications for theory in the construction management and economics, and hence for property management theory.

Initially, on the basis of the observation regarding a need for a regulatory framework in relation to response of construction industry to macro-economic factors, is an indication of the requirement for improvement in the way construction industry is currently operating including its management. The system of management of the construction industry in the country needs a management method like the one CBK uses to manage commercial banks in the country. CBK can apply its monetary policy to boost the production capacity of the industry. This can easily be achieved through the application of the macro-economic factors highlighted in this research to construction industry by way of selective credit control policy. In this way as observed in KNBS, (2014, 2015, 2016, 2017, 2018 & 2019) that huge sums used in the industry are borrowed, the industry will borrow more to deliver the constructed facilities and hence meet the demand in the country. Another tool the government can use in relation to the macro-economic factors to influence construction output in the country is the interest rate policy which can be fairly effective.

Consequently, it is appropriate for selective credit control and interest rate policy to touch on the real estate property in the country. Key to this point is that demand from real estate market is supplied by construction industry. Therefore, the mortgage interest rates can also be subject to these policies for purposes of creating an enabling environment for those interested in property development and investment in real estate.

Finally, some of the major problems the government is currently grappling with shall either be reduced to minimum or completely eradicated altogether. This shall be due to the adoption of the selective credit control and interest rate policies. The problems are namely unemployment in the country and provision of adequate housing. The chances of eliminating the two problems are going to be encouraged by steady growth of the construction industry which leads to more employment into the industry due to heightened activity and more constructed facilities including housing.

5.5 Implications for Construction Industry Policy

In brief, four policy recommendations may be given from the research findings in this study, as shown on Table 5.1.

Table 5.1: Research Findings and Policy Recommendations

Item	Finding	Section	Recommendation
1.	Construction output in Kenya in influenced by macro-economic factors	4.6, 4.7 & 4.9	Manipulation of macro-economic factors can be used as effective policy instruments to manage and control construction industry in Kenya.
2.	Macro-economic factors affect construction industry in Kenya as far back as twelve (12) years.	4.6 & 4.8	Policy guidelines towards fostering of construction growth in Kenya should be formulated by taking into account the impact of the factors.
3.	Construction industry in Kenya doesn't grow steadily.	4.3	Policy guidelines towards fostering of construction growth in Kenya should be formulated.
4.	The effects of macro-economic factors are not instantaneous.	4.7 & 4.9	CIDAC to continuously monitor the growth of the industry to ensure prompt delivery of its products.

As earlier stated, it is a matter of necessity to formulate and adopt policies which can aid and boost the capacity of construction industry. In this manner, policy targets in relation to deliverables by the industry shall be met. Therefore, it is extremely apparent that selective credit control and interest rate policy geared towards capacity building of the relevant industry players is very key and a positive undertaking.

The role played by construction industry in this country is quite important such that all efforts should be consolidated to ensure its continual improvement. Collaborations of relevant bodies as a sign of concerted efforts to come up with good and accurate policies are necessary at this point. Such bodies which are relevant to the construction industry include Ministry of Planning, Ministry of Public Works, National Construction Authority (NCA) and Central Bank of Kenya through the Monetary Policy Committee (MPC). It is therefore very likely to formulate policies through these public bodies which can enhance the industry's growth and furnish it with the necessary capacity to meet the ever-rising demand for constructed facilities in the country.

A number of ways are available to ensure proper policies regarding prop up of the construction industry in terms of giving it full potential of supplying adequate numbers of constructed facilities in the country. Firstly, it is through Ministry of Public Works (MOPW) and National Construction Authority (NCA) through which property developers and Building & Civil engineering contractors can be identified for purposes of advising Central Bank (CBK) through its Monetary Policy Committee (MPC) to apply selective credit control and interest rate policies to empower them. The move shall create a situation where the empowerment of these developers/contractors is done in such a way as to direct them towards achievement of some set goals; to deliver the 500,000 housing units as per the Agenda Four (4) Initiative within a specified period. Say for example one year. Secondly, a committee consisting of economic policy expert from CBK, construction project management experts and representation from NCA, MOPW and ministry of planning can be tasked with mandatory formulation of policies which can help to foster effective function of the industry in playing its role. The members in the committee shall play a substantive role of guarding against the interests of the body they represent. The committee can be given a title of Construction industry Development Advisory Committee (CIDAC). Lastly, since the Kenya Shilling is weak with regard to hard currencies, a policy guideline is necessary to encourage the use of locally available construction materials where possible. This shall discourage/limit the importation of construction materials which lead to high cost of construction projects.

5.6 Areas for Further Research

A case study research design was adopted in this study and therefore generalization of the findings is limited to the case - the construction industry of Kenya. Generalization is needed to other construction industries worldwide, which makes it necessary for survey research to achieve this in order to concretize the theory and policy implications of the influence of macro-economic variables.

Additionally, Vector Autoregression (VAR) Modeling of construction output in Kenya is necessary. A similar study as this one should be carried out involving other macro-economic factors. The modeling should be done using/applying consistent cointegration tests. This shall assist in establishing whether there are many more macro-economic factors affecting construction industry in Kenya. Examples of these additional macroeconomic factors is money supply, money remittances from abroad and credit to private sector from commercial banks. The factors were not included in this research due to their failure to meet time series threshold for inclusion in the research (Gerbing, 2016).

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APPENDICES

Appendix I: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 531416

Date of Issue: 22/November/2019

RESEARCH LICENSE

This is to Certify that Mr.. Emmanuel Mbusi of Jomo Kenyatta University of Agriculture and Technology, has been licensed to conduct research in Nairobi on the topic: Influence of Macro Economic Factors on Annual Construction Output Levels in Kenya for the period ending : 22/November/2020.

License No: NACOSTI/P/19/2368

531416

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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P. O. Box 30623, 00100 Nairobi, KENYA
Land line: 020 4007000, 020 2241349, 020 3310571, 020 8001077
Mobile: 0713 788 787 / 0735 404 245
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Appendix II: Introduction Letter

JOMO KENYATTA UNIVERSITY
OF
AGRICULTURE AND TECHNOLOGY
DEPARTMENT OF CONSTRUCTION MANAGEMENT

P. O. BOX 62000-00200, NAIROBI, KENYA. TEL: (020)-8008485
Fax: (067)-5352711 EXT 2475 Thika. Email: conmgmt@sabs.jkuat.ac.ke

To the Director,
National Commission of Science,
Technology & Innovation

3rd October, 2019

Dear Sir/Madam

SUBJECT: EMMANUEL THYAKA MBUSI ABS431-2314/2017

The above subject refers,

The above named person is a bonafide student of Jomo Kenyatta University of Agriculture and Technology pursuing the award of a PhD. degree in Construction Project Management.

His research thesis titled **"Influence of Macro-Economic Factors on Annual Construction Output Levels in Kenya"**

Any assistance given to him in this regard will be highly appreciated.

Thank you,

MARCAN W. MASUDI

COD, CONSTRUCTION MANAGEMENT

JKUAT is ISO 9001:2015 and ISO 14001:2015 Certified
Setting Trends in Higher Education, Research, Innovation and Entrepreneurship

Appendix III: Data Abstraction Sheet

Observation Year	CO KHS.	POP Growth Rate %	UEMP Rate %	CBWR %	IR %	ER USD/Kshs.
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
Observation Year	**CO KHS.**	**POP Growth Rate %**	**UEMP Rate %**	**CBWR %**	**IR %**	**ER USD/Kshs.**
2003						
2004						
2005						
2006						
2007						
2008						
2009						
2010						
2011						

2012						
2013						
2014						
2015						
2016						
2017						
2018						
2019						

Appendix IV: Raw Data

Year	CO	POPGR	UNEM	CBWR	IR	ER
1977	59.71	3.77	7.1	10	14.82	8.23
1978	66.87	3.8	7	10	16.93	7.73
1979	82.26	3.82	6.9	10	7.98	7.48
1980	96.33	3.85	6.9	10.58	13.86	7.42
1981	100.56	3.86	6.9	12.47	11.6	9.05
1982	120.58	3.87	6.8	14.5	20.67	10.92
1983	109.96	3.85	6.8	15.83	11.4	13.31
1984	102.48	3.8	6.7	14.42	10.28	14.41
1985	103.57	3.75	6.7	14	13.01	16.43
1986	107.30	3.68	6.7	14	2.53	16.23
1987	116.68	3.62	6.6	14	8.64	16.45
1988	121.68	3.55	6.6	15	12.27	17.45
1989	128.25	3.45	6.5	17.25	13.79	20.57
1990	135.10	3.38	6.8	18.75	17.78	22.92
1991	138.21	3.31	5.94	19	20.08	27.51
1992	182.56	3.23	6.25	21.07	27.33	32.22
1993	210.36	3.15	6.47	29.99	45.98	58
1994	254.07	3.07	6.53	36.24	28.81	56.05
1995	307.32	2.99	6.53	28.8	1.55	51.43
1996	657.68	2.91	6.61	33.79	8.86	57.12
1997	670.18	2.85	6.67	30.24	11.36	58.73
1998	2,507.70	2.8	6.7	29.49	6.72	60.36
1999	2,530.30	2.77	6.71	22.38	5.74	70.34
2000	2,492.00	2.75	7.04	22.34	9.98	76.18
2001	2,479.20	2.73	7.34	19.67	5.74	78.56
2002	32,373.00	2.71	7.89	18.45	1.96	78.75
2003	37,669.00	2.71	8.27	16.57	9.81	75.94
2004	48,079.00	2.72	8.42	12.53	11.62	79.17
2005	59,611.00	2.74	8.54	12.88	10.31	75.55
2006	71,216.00	2.76	8.52	13.64	14.45	72.1
2007	40,404.00	2.77	8.42	13.34	9.76	67.32
2008	43,735.00	2.77	8.74	14.02	26.24	69.18
2009	49,271.00	2.75	9.84	14.81	9.23	77.35
2010	51,486.00	2.72	9.78	14.37	3.96	79.23
2011	53,713.00	2.69	9.67	15.05	14.02	88.81
2012	154,816.00	2.66	9.73	19.72	9.38	84.53

2013	164,092.00	2.62	9.87	17.31	5.72	86.12
2014	185,514.00	2.56	9.62	16.51	6.88	87.92
2015	210,767.00	2.49	9.74	16.09	6.58	98.18
2016	232,246.20	2.42	9.69	16.56	6.3	101.5
2017	251,968.90	2.36	9.33	13.67	8.01	103.41
2018	268,646.20	2.31	9.39	13.06	4.68	101.3
2019	286,232.00	2.3	9.31	12.24	6.5	101.99

Appendix V: Regression Ouputs

ARIMA Model Regression

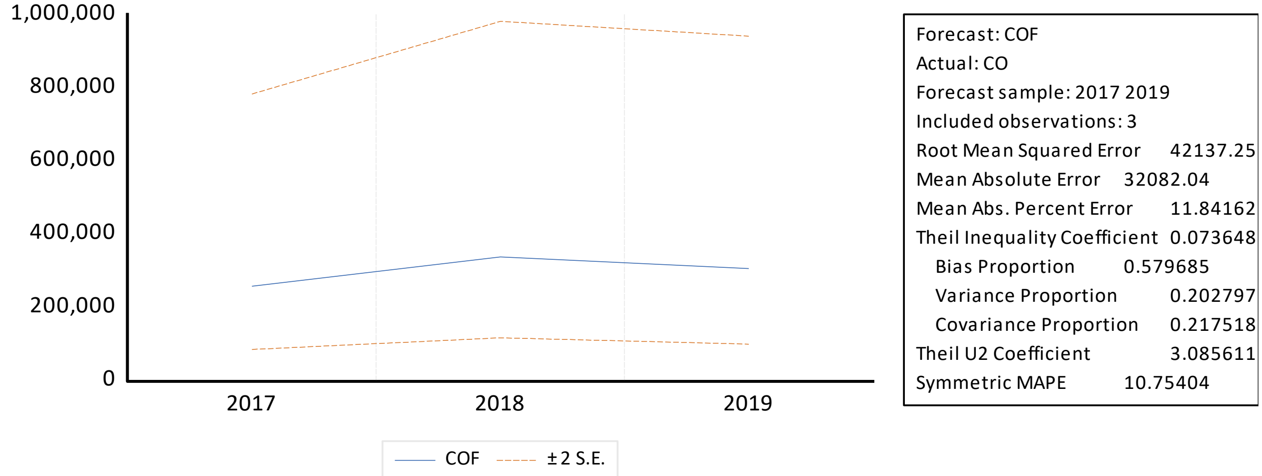
Dependent Variable: DLOG(CO)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 07/31/20 Time: 20:38
Sample: 1978 2019
Included observations: 42
Convergence achieved after 30 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.202361	0.132643	1.525604	0.1354
AR(1)	-0.949597	0.226808	-4.186782	0.0002
MA(1)	0.876415	0.375314	2.335151	0.0249
SIGMASQ	0.204254	0.041711	4.896911	0.0000

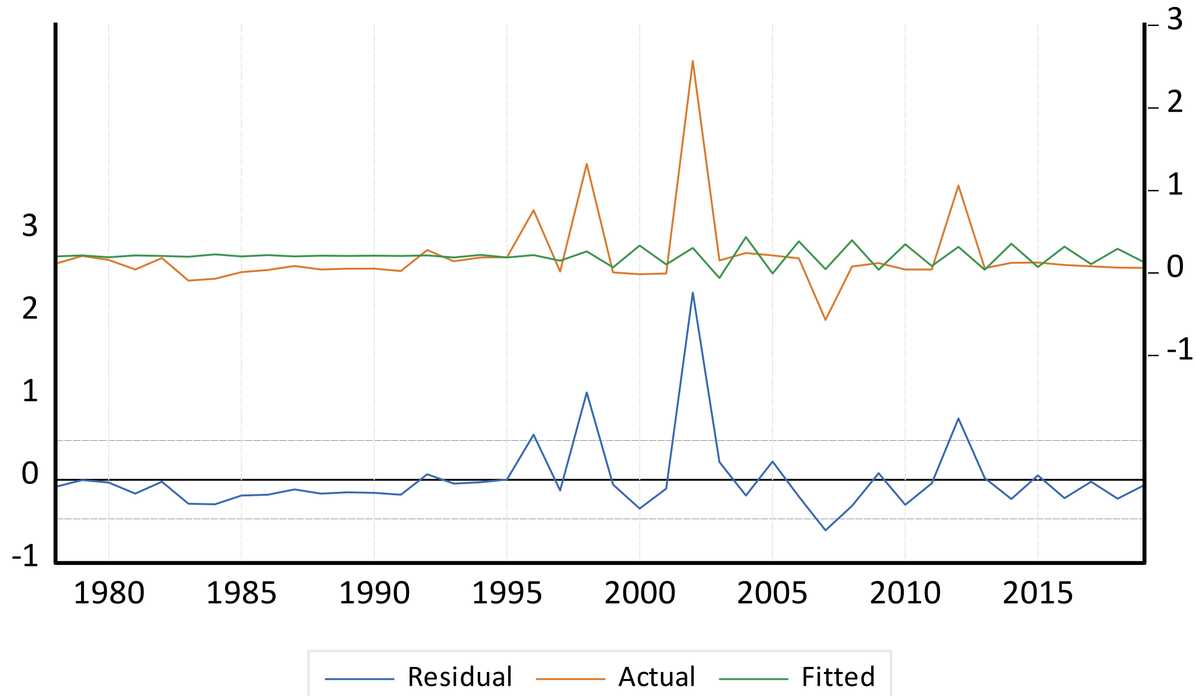
R-squared	0.068773	Mean dependent var	0.201787
Adjusted R-squared	-0.004745	S.D. dependent var	0.474013
S.E. of regression	0.475136	Akaike info criterion	1.444989
Sum squared resid	8.578678	Schwarz criterion	1.610482
Log likelihood	-26.34478	Hannan-Quinn criter.	1.505649
F-statistic	0.935460	Durbin-Watson stat	1.891140
Prob(F-statistic)	0.433033		

Forecast & Forecasting Evaluation Results of ARIMA Model

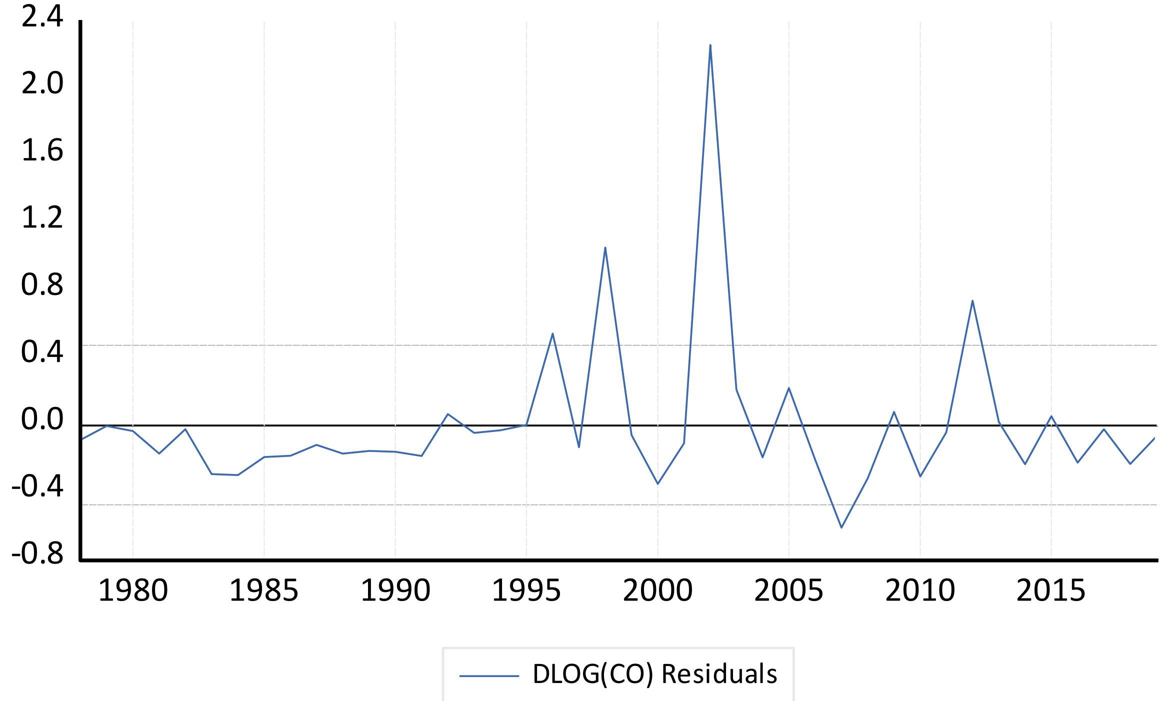
Accuracy in the Hold out Data



ARIMA Fitted Values and Residuals

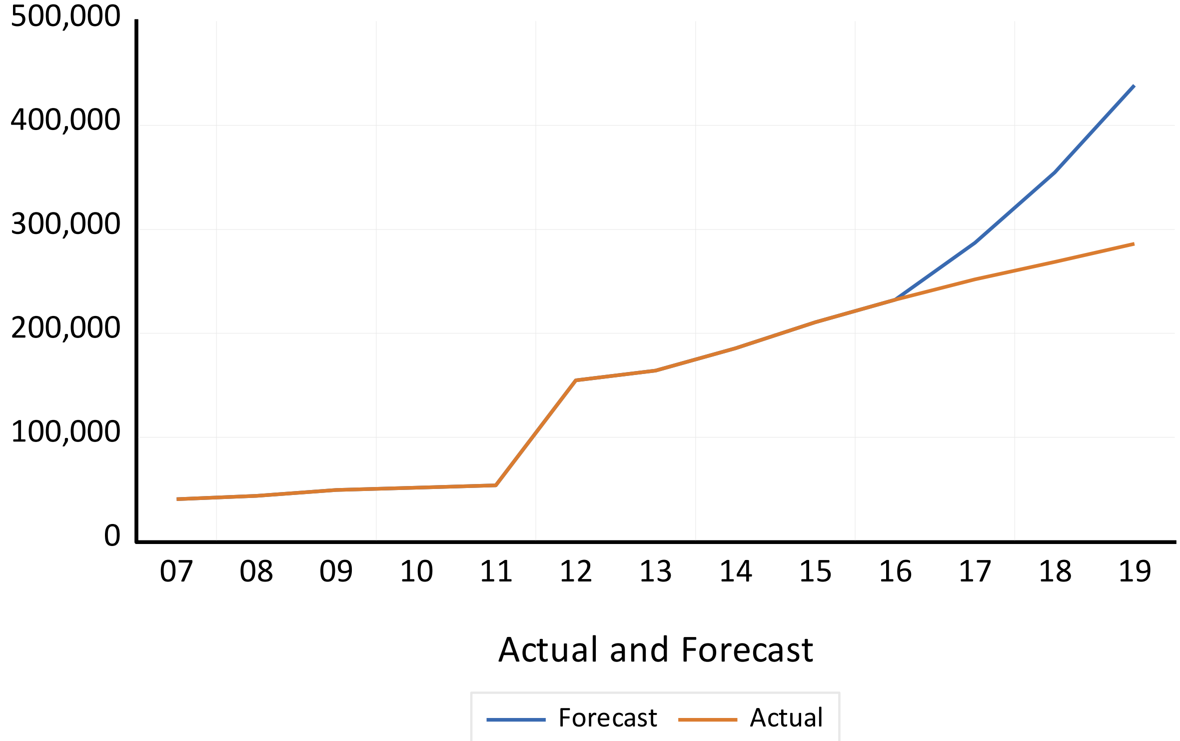


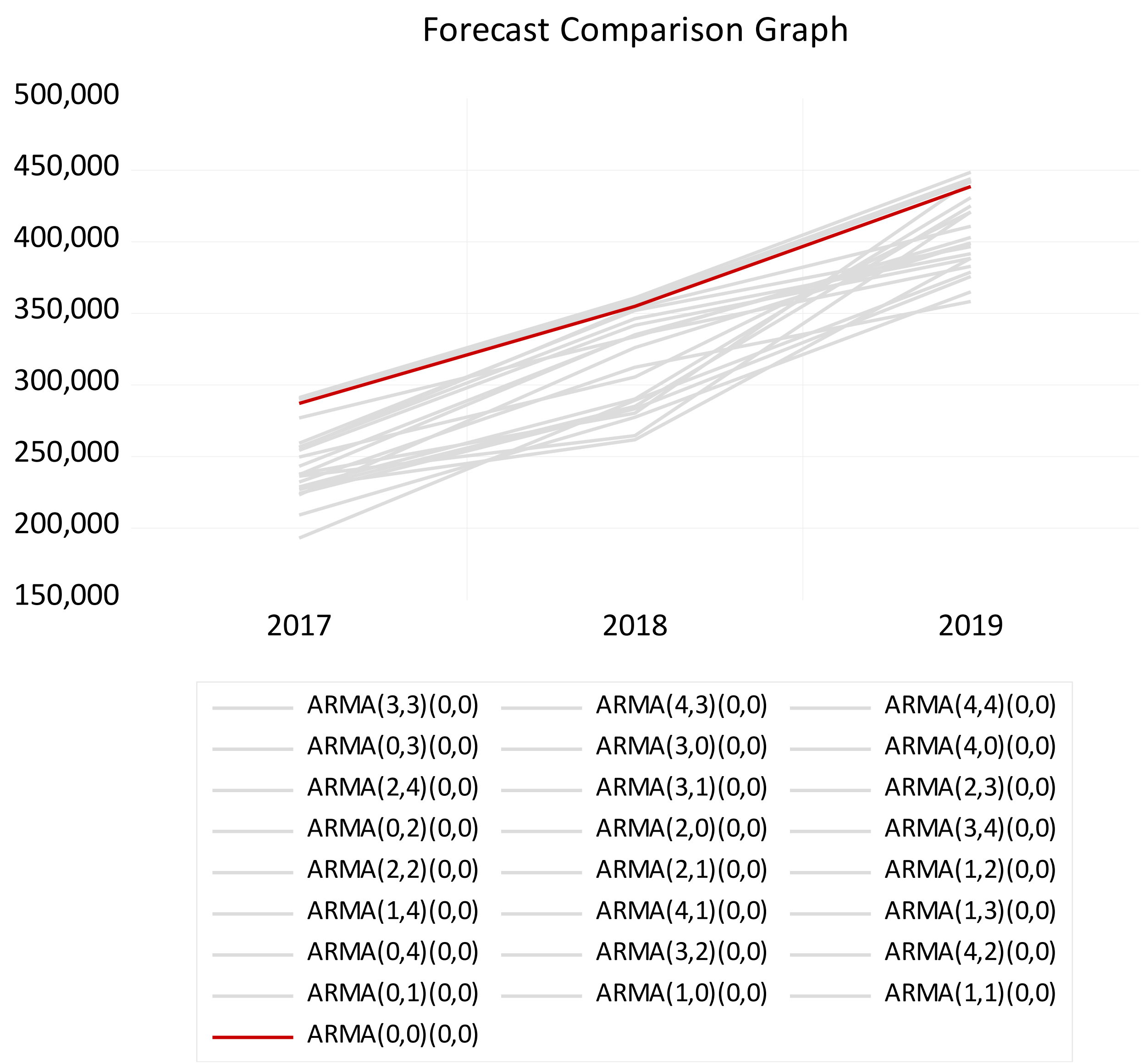
ARIMA Fitted Residuals

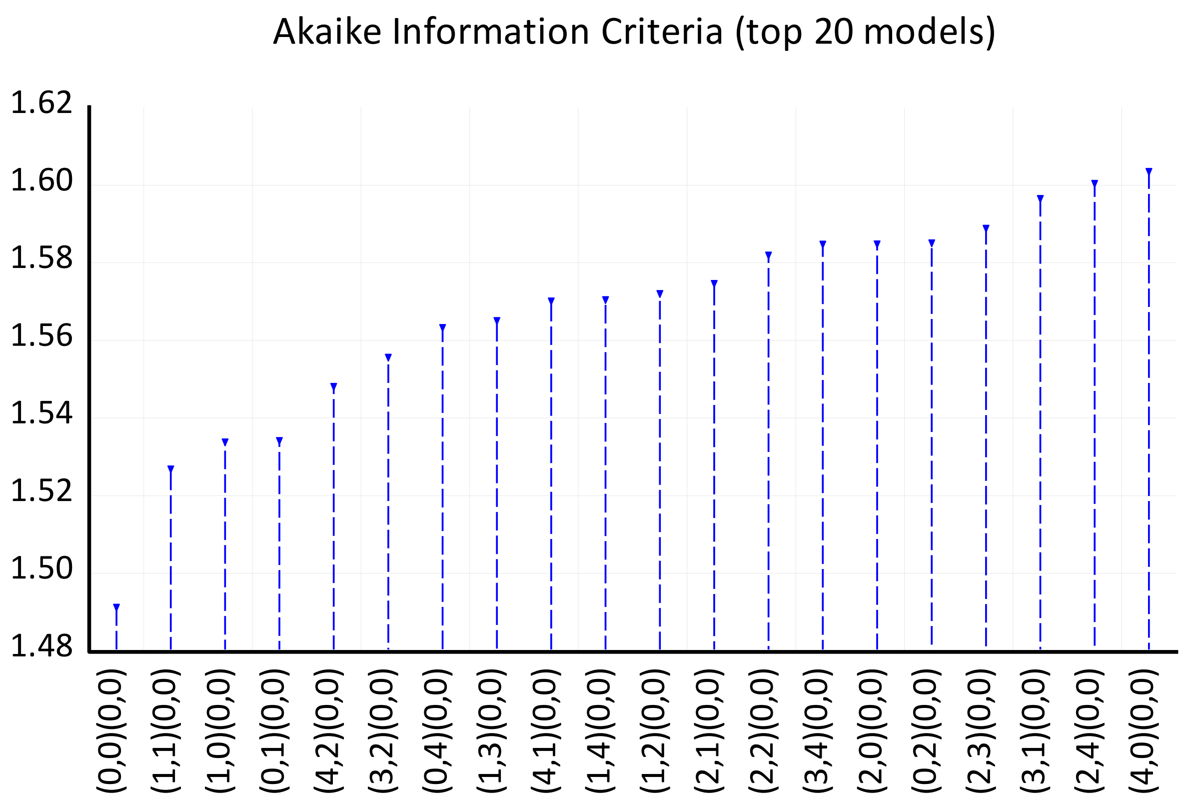


Automatic ARIMA Forecasting
Selected dependent variable: DLOG(CO)
Date: 08/02/20 Time: 17:06
Sample: 1977 2016
Included observations: 39
Forecast length: 3

Number of estimated ARMA models: 25
Number of non-converged estimations: 0
Selected ARMA model: (0,0)(0,0)
AIC value: 1.49124819017


500,000
400,000
300,000
200,000
100,000
0
07
08
09
10
11
12
13
14
15
16
17
18
19
Actual and Forecast
Forecast
Actual


Forecast Comparison Graph
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
2017
2018
2019
ARMA(3,3)(0,0)
ARMA(4,3)(0,0)
ARMA(4,4)(0,0)
ARMA(0,3)(0,0)
ARMA(3,0)(0,0)
ARMA(4,0)(0,0)
ARMA(2,4)(0,0)
ARMA(3,1)(0,0)
ARMA(2,3)(0,0)
ARMA(0,2)(0,0)
ARMA(2,0)(0,0)
ARMA(3,4)(0,0)
ARMA(2,2)(0,0)
ARMA(2,1)(0,0)
ARMA(1,2)(0,0)
ARMA(1,4)(0,0)
ARMA(4,1)(0,0)
ARMA(1,3)(0,0)
ARMA(0,4)(0,0)
ARMA(3,2)(0,0)
ARMA(4,2)(0,0)
ARMA(0,1)(0,0)
ARMA(1,0)(0,0)
ARMA(1,1)(0,0)
ARMA(0,0)(0,0)



Akaike Information Criteria (top 20 models)
1.62
1.60
1.58
1.56
1.54
1.52
1.50
1.48
(0,0)(0,0)
(1,1)(0,0)
(1,0)(0,0)
(0,1)(0,0)
(4,2)(0,0)
(3,2)(0,0)
(0,4)(0,0)
(1,3)(0,0)
(4,1)(0,0)
(1,4)(0,0)
(1,2)(0,0)
(2,1)(0,0)
(2,2)(0,0)
(3,4)(0,0)
(2,0)(0,0)
(0,2)(0,0)
(2,3)(0,0)
(3,1)(0,0)
(2,4)(0,0)
(4,0)(0,0)