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THE IMPACT OF OIL PRICE SHOCKS ON INFLATION

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DECLARATION

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the Research Project contains no material previously published or written by another person except where due reference is made in the Research Project itself.

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This Research Project has been submitted for examination with my approval as the Supervisor.

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Abstract

The issue that this study addresses is the lack of stability of consumer prices in Kenya. According to the National Energy and Petroleum Policy Report (2015), the fluctuating international prices of petroleum products and the volatile foreign exchange rates have led to unpredictable consumer prices within the country. The resulting cost-push inflation has led to an unsustainable increase in the cost of living from 2010. The purpose of this study is to investigate the impact of international oil price changes on inflation in Kenya. This will be done using a Vector Autoregressive Model and the model will control for exchange rates and interest rates. The study uses monthly data from 2000 to 2016. The variables examined are: domestic price levels, Murban crude oil prices, the Kenyan to US dollar exchange rates and the 91 day Treasury bill interest rates. The results indicate a positive correlation effect of oil price on inflation but no long run cointegrating relationship between these variables. The results also indicate the absence of an asymmetrical relationship between oil prices and inflation in Kenya. Lastly the results found that oil price had a uni-directional effect on domestic prices. Oil price also Granger-caused domestic prices indirectly through the exchange rate; that is, as oil price increases, this increases import prices and hence domestic prices. These results are useful in determining which relevant measures can be put in place by policymakers to address the problem of inflation and also add to the body of knowledge that seeks to understand the intuitive connection between oil price fluctuations and inflation rate.

CHAPTER 1: INTRODUCTION

1.1 Background to the study

According to U.S historical statistics, the direct relationship between oil price and inflation was evident in the 1970s, when the cost of oil rose from a nominal price of $3 before the 1973 oil crisis to close to $40 during the 1979 oil crisis. This was seen to cause the consumer price index (CPI), a key measure of inflation, to more than double from 41.101 in January 1972 to 86.30 by the end of 1980. This relationship was noticed again during the oil price hike from 1999 to 2008, in which the monthly average nominal price of oil started rising from the recent low point ($11.32) in January 1999 to $109.05 in April 2008. During this same period, the CPI rose from 164.30 in January 1999 to 214.82 in April 2008. (Lee B. et al., 2011)

Kenya is solely reliant on oil imports to satisfy its oil needs. The Ministry of Energy provides the policy leadership, while the Energy Regulatory Commission (ERC) provide stewardship of the sub-sector (Bett 2017). While the ERC is charged with the responsibility of cushioning the country from exploitation by oil companies, the Energy Policy of 2004 states clearly that government will let market forces determine prices. Therefore the oil price fluctuations that happen globally are transmitted to the local economy. This is due to the fact that Kenya still operates under the Open Tender System (OTS) in the importation of crude from the Gulf Region. According to KPRL (Kenya Petroleum and Refineries Limited) the main source of Kenyan crude oil is Murban Crude oil from Abu Dhabi in the United Arab Emirates. The price of which is subject to global market forces. The ERC uses a formula for pump prices which incorporates the international crude or refined product prices, freight, local transportation costs, financing, insurance, the refinery processing fees, taxes and a profit margin (Bett 2017). Therefore changes in the international oil prices are directly transmitted and reflected in the local pump prices. An increase in diesel prices leads to an increase in farming costs, the cost of inputs in the manufacturing and transport sectors and subsequently an increase in consumer prices making Kenyan products uncompetitive. With the income of consumers remaining relatively constant, these increases lead to erosion of purchasing power of the consumers in addition to reducing monies for other needs. (National Energy and Petroleum Policy 2015)

A large body of empirical research has confirmed that oil price increases have strong and negative influences for the real economy (e.g., Hamilton, 1983; Burbidge and Harrison, 1984; Gisser and Goodwin, 1986; and Cuñado and Pérez de Gracia, 2003). However, since the rapid fall of oil price in 1986, the established model has been challenged. Some theoretical and empirical work has suggested that the relationship between oil prices and economic activity is not entirely linear. Mork (1989) extends the analysis of Hamilton (1983) and shows that there is an asymmetric relationship between oil prices and output growth. He establishes, in particular that economic growth has a significant negative correlation with oil price increases, but an insignificant positive correlation with oil price decreases. In other words, he showed that oil price increases have a proportionally greater (and negative impact) on economic activity than the corresponding positive impact of a decrease. Consequently it may be reasonable for this study to test whether there is an asymmetric response behavior exhibited within the data that is being examined.

Although a considerable amount of research has found that oil price shocks have affected the real output, only a few emphasize the effects of inflation. Blanchard and Galí (2007) examined the effects of the recent oil shock on output and inflation and attempted to answer why the current shocks (as in the 2000s) have had smaller effects on output and inflation than that in the 1970s. De Gregorio et al. (2007) provided a variety of estimates of the degree of transmission from oil prices to inflation over time for a large set of countries. Moreover, using a structural cointegrated VAR model for G-7 countries, Cologini and Manera (2008) found that for all countries except Japan and U.K., changes in oil prices did influence the inflation rates.

This study attempts to add to the body of knowledge that seeks to understand the intuitive connection between oil price fluctuations and inflation rate by investigating the impact of international oil price changes on inflation in Kenya. This study examines whether oil price changes generate inflation and whether the asymmetric response behavior exists in the sample period.

1.2 Problem Statement

The interest of this study is propelled by the need to empirically measure the effect of oil price changes on inflation in Kenya. The issue of oil price changes is crucial as oil prices affect macroeconomic indicators of every country. According to the National Energy and Petroleum Policy Report in 2015 the fluctuating international prices of petroleum products and the volatile foreign exchange rates have led to unpredictable consumer prices, more so in the local pump prices. From 2010 the resulting cost-push inflation has led to unsustainable increase in the cost of living. Since oil price fluctuations have such major implications on this Kenya, which is an oil importing country, then now is surely the time to empirically evaluate and determine the relationship between oil prices, exchange rates and inflation using a robust model which accounts for the asymmetrical responses of inflation from oil price changes.

1.3 Research Objectives

1.3.1 General Objective

By using time-series data for oil prices, consumer price indexes, exchange rates, and interest rates, this paper aims to analyse the influence of oil price change on inflation.

1.3.2 Specific Objectives

1) Determining whether oil price changes generate inflation.

2) Determining whether the asymmetric response behavior exists in the sample period.

1.4 Research Questions

1) Do oil price changes generate inflation? If so, how does inflation respond? And what is the magnitude of the response?

2) Does the asymmetric response behavior exist in the sample period? If so, does the impact of oil price increase on the level of inflation rate differs from that of oil price decrease?

1.5 Justification

From the point of view of academia, by empirically testing the local context, this study adds to the body of knowledge that seeks to understand the intuitive connection between oil price fluctuations and inflation rate.

From, the point of view of policymakers, the study will reveal how changes in the international price of oil can cause inflation in Kenya, this information can then be used to determine which relevant measures can be put in place to address the problem of inflation.

CHAPTER 2: LITERATURE REVIEW

2.1 Oil and Economic Activity: Transmission channels and Related Works

2.1.1 Theoretical review of the literature

According to Khan (2011) it can be argued that in the short-run oil price shocks affect macroeconomic performance through various channels. Theoretical literature has identified six transmission channels through which oil price changes affect the performance of macroeconomic variables [Brown and Yucel (2002); Jones, et al. (2004); Tang, et al. (2010), Khan (2011)]. These transmission channels include the supply-side shock effect, wealth transfer effect, inflation effect, real balance effect, sector adjustment effect and the psychological effect. According to supply-side effect, rising oil prices are indicative of the reduced availability of a basic input to production, leading to a reduction of potential output [Lescaroux and Mignon (2008)]. Consequently, there is an increase in the marginal costs of production and the growth of output and productivity are slowed [Lescaroux and Mignon (20080 and Tang, et al. (2010)]. The decline in productivity growth negatively affects real wages and increases unemployment [Kumar (20090; Chuku et al (2010)]

The second important transmission channel of oil price shocks is the wealth transfer effect. This channel suggests that increase in oil prices shifts purchasing power from oil importing countries to oil-exporting countries. A persistent rise in oil price would consider being a significant windfall in revenue and improvement in balance of payments of oil exporting countries. The transfer of wealth is expected to reduce the aggregate demand of the oil-consumer countries while opposite is expected in the case of oil-producing countries [Khan (2011)], because it is assumed that marginal propensity to consume in the oil-exporting countries is higher. The oil price shocks in oil-importing countries are transmitted through the demand-side by triggering the reduction of demand for goods and services. High oil prices may affect consumer expenditures via four complementary channels: discretionary income effect, uncertainty effect, precautionary saving effect and operating costs effects [Kilian (2010) and Chuku, et al. (2010)]. This implies that an increase in oil prices deteriorates terms of trade for oil-importing countries [Khan (2011)].

Besides the slowing down total output, a hike in oil price generates inflationary pressures in the economy [Tang, et al. (2010)]. Since oil-based products are an important components of consumer price index. The first round effect of high oil prices is a sudden increase of the headline inflation. However, the degree of pass through effect depends on the domestic response to the shocks [Galesi and Lombardi (2009)]. Evidence suggests that reduced output and inflation are the two most likely effects of oil price shocks [Chuku, et al. (2010)]. An oil price shocks constitutes a cost of production shocks, operating through supply-side effect which produces upward pressure on labour costs and prices [Khan (2011)]. Barsky and Kilian (2004) showed that increases in oil price generate high inflation. This can also be interpreted as price shock second round effects, giving rise to wage-price loops [Galesi and Lombardi (2009)].

According to the real balance effect transmission channel, an increase in oil prices would lead to increase in demand for money. Since the monetary authorities failed to meet growing money demand with increased money supply. Consequently, there is an increase of interest rates and retard of economic growth [Brown and Yucel (2002)]. Alternatively, working through the price-monetary transmission mechanism, oil price shocks can reduce investment due to the reduction in producer's profits and equally reduces money demand (Figure 1).

The monetary policy channel is another important channel through which monetary authorities respond to oil price shocks. For example, tightening of monetary policy through increased interest rates (Figure 1) to combat inflationary pressure caused by rising oil prices, discourage investment and worsens output in the long-run [Tang, et al. (2010)]. [Brenanke, et al. (1997); Khan (2011)] Tightening of monetary policy and oil price shocks produced depressing effects on real economy.

The sectoral adjustment effect channel shed light on the asymmetric impact of oil price shocks within the sectors of the economy. When oil price rise, slowing economic activities is further retarded by adjustment costs. Conversely, when oil price falls, stimulated economic activities is somewhat offset by adjustment costs [Brown and Yucel (2002 and Chuku, et al. (2010) Khan (2011)]. Such costs could arise from sectoral imbalances and lack of coordination between firms or because energy-to-output ratio is embedded in the capital stock [Brown and Yucel (2002) and Lescaroux and Mignon (2008)]. In the presence of sectoral imbalances, an increase (decrease) in oil price would require contraction (expansion) of oil intensive sectors and expansion (contraction) of oil efficient sectors [Lilien (1982) and Hamilton (1988)]. These realignments in production require adjustments, which cannot be achieved in the short run-known as dispersion hypothesis [Khan (2011)]. Furthermore, asymmetry in oil prices will result in under-utilisation of resources and rising unemployment.

Finally, psychological effect according to Khan (2011) implies that given the uncertainty about how long will oil prices remain high can adversely affect economic activities by reducing investment demand of firms and consumer's demand-known as the uncertainty channel. Uncertainty causes firms and consumers to postpone irreversible investment and consumption decisions following positive oil price shocks [Bernanke (1983); Ferderer (1996) and Galesi and Lombardi (2009)].

Keynesian theory on Cost push inflation

Keynes theory of cost-push inflation attributes the basic cause of inflation to supply side factors. Cost-Push inflation occurs when the price of production increases causing manufacturers to increase prices for their products in order to protect profit margins. The world economy depends on oil as source of energy and therefore changes in the price of oil as a basic input will always impact on the consumers' prices. If there is an increase in the price, then it will lead to higher production cost hence higher consumer prices and vice versa. The oil shocks generally result in severe cost-push inflation, for example the 1973-1974 and 1970-1980 crises.

Hunt et al. (2001) pointed out that increases in the input costs could result in a downward trend of non-oil potential output supplied in the short run given existing capital stock and sticky wages. When inflation levels are high, workers and producers will counter the value deterioration in their real wages and profit margins; this will further put upward pressure on unit labour cost and prices of finished goods and services. Oil is a major input in most sectors of the economy and therefore any changes will lead to automatic changes in a firm's cost of production, upward or downward.

According to the Real Business Cycle theory developed in the 1980s the supply channel of transmission was reinforced whereby oil shocks act as a supply shock in the economy. Oil shocks therefore are the real shocks to the economy and the primary cause of the business cycle and these can be defined as disturbances to the real side of the economy. Business cycles are always influenced by the oil shocks globally within the real business cycle. The production function, the size of labour force, real government expenditure and the saving and consumption decisions of consumers are affected by these shocks (Abel and Bemanke 1992).

2.1.2 Empirical Review of the Literature

Some theoretical and empirical work has suggested that the relationship between oil prices and economic activity is not entirely linear. Authors have focused mainly on three possible explanations of the assymetric responses of macroeconomic variables to oil price shocks: counter-inflationary monetary policy responses to oil price increases, sector shock transmission mechanisms, and investment uncertainty [Hamilton (1988), Mork et al (1994), Arouri et al (2011)]. Mork (1989) extends the analysis of Hamilton (1983) and shows that there is an asymmetric relationship between oil prices and output growth. He establishes, in particular that economic growth has a significant negative correlation with oil price increases, but an insignificant positive correlation with oil price decreases. In other words, he showed that oil price increases have a proportionally greater (and negative impact) on economic activity than the corresponding positive impact of a decrease. This is often witnessed in Kenya where commodity price increases quickly follow upward oil price changes but rarely do they come down following a fall in world oil prices (Bett 2017)

Davis and Haltiwanger (2001) distinguish between aggregate transmission mechanisms (effects of increases in the price of oil on potential outcome, income transfer and sticky wages) and allocative transmission mechanisms (effects of oil price changes on the closeness of the match between firms' desired and actual levels of labour and capital). The allocative transmission mechanisms should operate asymmetrically since both oil price increases and decreases would change firms' desired employment structures, whereas the aggregate channels should operate symmetrically. Based on this analysis, Davis and Haltiwanger (2001) show that the responses of the economy to oil price increases are considerably larger than those to oil price decreases. Lee and Ni (2002) establish that more energy-intensive industries tend to experience oil price shocks as supply shocks (aggregate impacts) and less energy-intensive industries as demand shocks (allocative impacts).The asymmetric relationship between oil shocks and economic growth is supported by a series of more recent empirical works employing more robust econometric techniques [Hamilton (2003)]. These works confirm that oil price increases appear to retard aggregate economic activity by more than oil price decreases stimulate it. However, as we mention years economic growth was associated with increases of higher demand and investor sentiment [Barsky and Killian (2004), and Killian (2008, 2009)].

2.2 International oil prices and inflation in Kenya

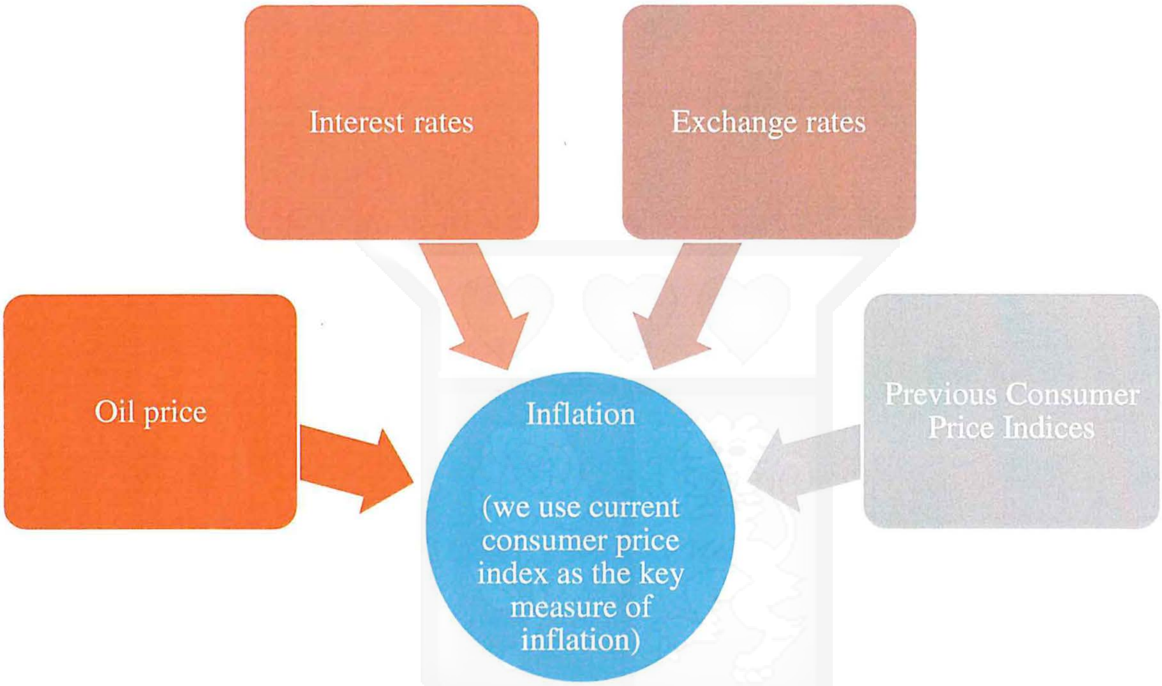
From 2013, the country has continued to experience a relatively low and stable inflation, moderate interest rates and a relatively stable shilling against the major trading currencies, albeit with some depreciation in the second half of 2014. In 2012 overall inflation was 9.4 percent, dropping to 5.7 percent in 2013 before increasing marginally to 6.9 percent in 2014. The main drivers for the general easing of inflationary pressures include improved supply of basic foods, lower international oil prices and lower costs of electricity, East Africa Community (EAC) integration, Information and Communication Technology (ICT) innovations, strong macroeconomic management and recent investments in infrastructure. (National Energy and Petroleum Policy 2015)

Kenya is solely reliant on oil imports to satisfy its oil needs. The Ministry of Energy provides the policy leadership, while the Energy Regulatory Commission (ERC) provide stewardship of the sub-sector (Bett 2017). The ERC, the industry regulator, has several functions as set out in the Energy Act, 2006, which include regulation of importation, exportation, transportation, refining, storage, protecting consumers, investors and other stakeholder interests and monitoring fair competition in the energy sector. While this body is charged with the responsibility of cushioning the country from exploitation by oil companies, the Energy Policy of 2004 states clearly that government will let market forces determine prices. Therefore the oil price fluctuations that happen globally are transmitted to the local economy. This is due to the fact that Kenya still operates the Open Tender System (OTS) in the importation of crude from the Gulf Region. According to KPRL (Kenya Petroleum and Refineries Limited) the main source of Kenyan crude oil is Murban Crude oil from Abu Dhabi in the United Arab Emirates. The price of which is subject to global market forces. The ERC uses a formula for pump prices which incorporates the international crude or refined product prices, freight, local transportation costs, financing, insurance, the refinery processing fees, taxes and a profit margin (Bett 2017). Therefore changes in the international oil prices are directly transmitted and reflected in the local pump prices.

A number of geo-political issues have affected international oil prices causing price volatility. These include the unrest in the Middle East countries, reduction in production by OPEC, piracy in the Indian Ocean, increased demand for petroleum products worldwide, foreign exchange fluctuations and fluctuations in the USA strategic reserves and recently the production of oil from oil shale in the USA. The world economy emerged from the recession experienced in 2009 recording a significant growth of 4.6% in 2010. This influenced world oil demand and supply. In 2011 Murban crude oil prices fluctuated rapidly with the lowest at US$95.6 per barrel (bbl) in January, peaking to US$120 bbl in April and averaging at more than US$110bbl most of the year. In 2012 the average price went up by 3.1% to US$112.97 bbl and US$110 bbl in 2013 being a decrease of 2.5%. Whereas high international oil prices and a weak Kenya Shilling vis-a-vis the hard currency have led to spikes in prices of petroleum products in the domestic market creating inflationary pressure on prices of commodities. (National Energy and Petroleum Policy 2015). In addition, the fluctuating international prices of petroleum products and the volatile foreign exchange rates have led to unpredictable consumer prices, more so in the local pump prices. From 2010 the resulting cost-push inflation has led to unsustainable increase in the cost of living.

2.3 Conceptual framework

The variables are presented in a visual map indicating the relationship the study intends to determine.



2.4 Research Model

Dependent variable – Inflation measured by CPI

Independent variables – Oil price, consumer price indexes, exchange rates, interest rates

Since the monetary policy is the primary tool to prevent inflation. Central banks may fine-tune inflation to a significant extent through targeting interest rates. On the other hand, previous papers have found that interest rate was an important factor to be included in the discussion of the oil price-GDP relationship such as Huang et al. (2005) and Huang (2008). For this reason, we choose the interest rates as one of our control variables in the model. Moreover, exchange rate has been largely omitted from the related literature, thus the inclusion of this variable seems appropriate because it surely play a major role in monetary policy in the international economy. Accordingly, it is also necessary to take exchange rate into account. As such, the study on the response of inflation from oil price changes should include oil price change (t Δlroilp), inflation rate (t Δlcpi), interest rate change (t Δr), and exchange rate change (t Δer). (Lee B., et al., 2011)

Following (Lee B., et al., 2011) we estimate the model in various ways. The dependent variable of the model is the log change in CPI, and all the explanatory variables are lagged. Apart from the log change of CPI and oil price variables, there are interest rate change and exchange rate change. In absent of long-run equilibrium among the variables and with the presence of asymmetrical transmission from oil prices to inflation rates, we present the following model:

$$\Delta lcpi_t = \sum_{i=0}^{p} \alpha_i^+ \Delta lroilp_{t-i}^+ + \sum_{i=0}^{p} \alpha_i^- \Delta lroilp_{t-i}^- + \sum_{i=1}^{p} \gamma_i \Delta r_{t-i} + \sum_{i=1}^{p} \delta_i \Delta er_{t-i} + \sum_{i=1}^{p} \beta_i \Delta lcpi_{t-i} + \mu_t \qquad (1)$$

where + Δ t lroilp and – Δ t lroilp are respectively real oil price increases and real oil price decreases, Δlcpi ,Δlroilp , Δr,and Δer represent respectively the difference of consumer price index and real oil price (after logarithm) as well as the difference of interest rates and exchange rates. The residual, μt , is assumed to be independently and identically distributed with N(0,1). The optimal lag length in the model is chosen by minimizing the Akaike information criterion (AIC). Note that we include the current variable of oil price changes in the right hand side because it would help us to capture its current impact on inflation rates.

If there is neither relationship among the variables nor asymmetrical responses of inflation from oil price changes, equation (1) can be reduced to a linear regression model as described in equation (2):

$$\Delta lcpi_t = \sum_{i=0}^{p} \alpha_i \Delta lroilp_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta r_{t-i} + \sum_{i=1}^{p} \delta_i \Delta er_{t-i} + \sum_{i=1}^{p} \beta_i \Delta lcpi_{t-i} + \mu_t \qquad (2)$$

If there is a cointegration relationship among the variables in conjunction with the presence of asymmetrical relation between oil price changes and inflation rates, our four-variable estimation equation can be specified as in equation (3):

$$\Delta lcpi_t = \sum_{i=0}^{p} \alpha_i^+ \Delta lroilp_{t-i}^+ + \sum_{i=0}^{p} \alpha_i^- \Delta lroilp_{t-i}^- + \sum_{i=1}^{p} \gamma_i \Delta r_{t-i} + \sum_{i=1}^{p} \delta_i \Delta er_{t-i} + \sum_{i=1}^{p} \beta_i \Delta lcpi_{t-i} + \lambda \varepsilon_{t-1} + \mu_t \qquad (3)$$

where the $\varepsilon_{t-1} = (lcpi_{t-1} - \theta lroilp_{t-1} - \rho r_{t-1} - \phi er_{t-1})$ is the error correction term in $t-1$

If there are no asymmetrical responses of inflation rates from oil price changes, equation (3) becomes a long-run linear model as expressed in equation (4):

$$\Delta lcpi_t = \sum_{i=0}^{p} \alpha_i \Delta lroilp_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta r_{t-i} + \sum_{i=1}^{p} \delta_i \Delta er_{t-i} + \sum_{i=1}^{p} \beta_i \Delta lcpi_{t-i} + \lambda \varepsilon_{t-1} + \mu_t, \qquad (4)$$

CHAPTER 3: METHODOLOGY

3.1 Research Design

The research undertaken fits a descriptive research design. This is due to the fact that descriptive studies are usually the best methods for collecting information that demonstrate relationships between the variables as they are.

3.2 Data

In this section we examine the oil price-inflation relationship, by means of estimating the impact of oil price changes on consumer price index. We consider monthly data of the average price of Murban crude oil (OILP) together with the consumer price indexes (CPI), interest rates (R), and exchange rates (ER). Real oil prices are defined as the U.S. dollar prices of average crude oil deflated by the domestic (local) consumer price index. Real oil prices and CPI are measured in logarithms. We use monthly data from the year 2000 to 2016 and the analysis is carried out using stata and gretl software.

3.3 Methodology

3.3.1 Unit Root Tests

As a first step in the empirical analysis, we perform unit root tests to confirm the integrational properties of the data series.

3.3.2 Engle Granger Cointegration Test

To test for a long-run cointegrating relationship among the variables, we apply the Engle Granger cointegration test.

3.3.3 Specification and Estimation of the Econometric Model.

After application of the Engle Granger cointegration test, if there is at least one cointegrating relationship among the variables then we proceed to specify and estimate an error correction model but if there is no cointegrating relationship present among the variables then we proceed to specify and estimate a vector autoregressive model.

3.3.4 Diagnostic Check

To evaluate the statistical properties of the model, a series of tests was conducted to check if the model performs well on statistical grounds. This entails a test of autocorrelation, a test of autoregressive conditional heteroscedasticity (ARCH) on heteroscedasticity and finally a test of normality. The goal of this diagnostic checks is to ensure that there is no autocorrelation within the model, there is absence of autoregressive conditional heteroscedasticity within the model and that the residuals are normally distributed.

3.3.5 Granger Causality

An important issue in estimating a vector autoregressive model is to determine whether movements in one variable are caused by movements in another. If Granger Causality Test suggest that the stationary series does not cause or is not caused by other series, that is all the coefficients regarding this series are found not significantly jointly, we should drop this series. We apply the granger causality test to show the presence of short-run reactions from oil price changes to inflation rates.

3.4 The Econometric Technique.

Vector Autoregression (VAR)

The essence of regression analysis is to estimate the long run economic relationships in order to test economic theory. The VAR methodology is a better approach for investigating the long-run relationship because it approximates well the unknown model of true economic structure by taking dynamic interactions among the variables in the system into consideration. (Kpogli 2014)

Conventionally, econometric investigations are carried out through extensive models. Typically, a full set of structural equation is estimated. In order to identify the impact of policy variables in the model, the investigation is designed at conveying a value to the policy instrument that will achieve a given target for macroeconomic variables. The model assumes that the policy variables are exogenous on the grounds that these variables are the instruments controlled by the policy makers. (Kpogli 2014)

The main development of VARs as a modelling tool was in the early 1980s, originating from concerns about the validity of some of the assumptions used in traditional macro econometric models. In particular, it is argued that the restrictions used to identify the parameters in traditional models - which often took the form of excluding variables or their lags from equations or assuming that a particular variable was exogenous - were 'incredible'. It was contended that theory was rarely sufficiently well-defined to justify such exclusion restrictions or exogeneity assumptions, and that such models were likely to be under-identified once these problems were taken into account. As a result, some of the economic interpretations drawn from such models were unlikely to be robust.

The above concerns led to the development of VAR as an alternative modelling approach. VARs are dynamic systems of equations in which the current level of each variable in the system (CPI, oil price, exchange rate or interest rate) depends on past movements in that variable and in all the other variables in the system. In contrast with traditional models, basic VAR systems make few assumptions about the underlying structure of the economy and instead focus entirely on deriving a good statistical representation of the past interactions between economic variables, letting the data determine the model.

However, even VARs are not completely devoid of assumptions, since the choice of variables to include in the system and the length of lags allowed represent a type of restriction, which can have important implications. Nevertheless, the VAR approach is useful for exploring what a given theoretical view implies for the dynamic behavior of the variables of interest.

Thus a benefit of the VAR approach is that it does not entail any strict economic theory within which the model is grounded. Most of the empirical literature has analyzed the relationship between oil prices and key macroeconomic variables using some type of a VAR framework (Kpogli 2014). The cointegration analysis and VAR technique can be used to model the long-run and short-run relationships between non-stationary variables. Cointegration techniques are used to establish whether or not a long run equilibrium (i.e. stationary) relationship exists between non-stationary variables in a single or system of equation(s). Such long-run relationships are normally hypothesized by economic theory, where the theory postulates the existence of an equilibrium relationship that links the variables in question. The concept of cointegration is in essence a statistical characterisation of a situation where the variables in the hypothesized relationship should not diverge from each other in the long run, or if they should diverge from each other in the short-run, this divergence must be stochastically bounded and diminishing over time (Banerjee et al., 1993:136).

3.5 Description and Justification of Explanatory Variables

Oil price

It is important to note that the choice of oil price variable to use, which is between the world oil price and national oil price are difficult and relevant. National oil prices are influenced by many factors such as price controls and taxes on petroleum products. Therein lies one of the limitations of the study. In as much as the ERC now sets the price locally, this practice only started in January 2011, and therefore local data is not available for the entire study period. However, close inspection of the ERC price reveals that they are anchored on the international import prices while carefully controlling the margins made by local importers in a bid to protect the end consumer. Taking that into account, the use of the international oil price is justifiable to the extent that the price change experienced globally is reflected locally. (Bett 2017)

Interest rate

Interest rate is one of the important instruments for monetary policy. It is also an important variable in the money, goods and capital market; since the monetary policy is the primary tool to prevent inflation. Central banks may fine-tune inflation to a significant extent through targeting interest rates. For this reason, the study chooses the interest rates as one of its control variables in the model. The 91-Day Treasury bill rate is used as proxy for interest rate since Treasury bill serves as the opportunity cost of holding money or shares and as a benchmark for measuring interest rate. (Kpogli 2014)

Exchange rate

The inclusion of the real exchange rate can be seen from the fact that crude oil prices are quoted in US dollars, which in turn, determines the domestic prices of petroleum products. The exchange rate is the price of domestic foreign currency in terms of domestic currency. According to Kpogli (2014), changes in the exchange rate are different from changes in one tradable good price. Whereas changes in one good price affect only the relative price of the good concerned, changes in the exchange rate affect the prices of all tradable and their relative prices in terms of non-tradable; the exchange rate has a wealth effect .

Moreover, exchange rate has been largely omitted from the related literature, thus the inclusion of this variable seems appropriate because it surely play a major role in monetary policy in the international economy (Kpogli 2014). It is also important because we need US dollars to be able to import crude oil in Kenya hence the use of Kenyan shilling/US Dollar rate as a proxy for exchange rate.

CHAPTER 4: ANALYSIS AND DISCUSSION OF RESULTS

4.1 **Data Description and sources.**

To examine the oil price-inflation relationship in Kenya, secondary data was used. The study used monthly data which span the period of 2000 to 2016. All the variables used for the study are presented in the table below with their definitions and sources.

Table 1: Definitions and sources of variables

Variable	**Definition**	**Source**	**Denotation**
Domestic price level	Consumer Price Index	Central Bank of Kenya website	CPI
Oil price	Murban crude oil prices	OPEC website	OILP
Exchange rate	Kenyan shilling/ US dollar rate	Central Bank of Kenya website	ER
Interest rate	91 day-treasury bill	Central Bank of Kenya website	R

4.2 Descriptive analysis

Table 2: Summary of descriptive statistics

	LCPI	LOILP	LER	LR
Mean	4.517312	8.407699	4.387514	-1.84117
Standard deviation	0.4019937	0.5658845	0.113323	0.1703556
Minimum	3.840357	7.293165	4.125504	-2.122767
Maximum	5.165808	9.295374	4.656576	-1.370815
Observations	204	204	204	204

Note ; LCPI denotes log of domestic price level, LOILP represents log of oil price, LER is the log of exchange rate, LR denotes log of the interest rate and R is the interest rate.

4.3 Correlation analysis

Table 3: Correlation matrix

	LCPI	LOILP	LER	LR	R
LCPI	1.0000				
LOILP	0.7831	1.0000			
LER	0.6698	0.2229	1.0000		
LR	-0.1032	-0.2487	0.2595	1.0000	
R	-0.1499	-0.2773	0.2219	0.9958	1.0000

The correlation matrix indicates a significant positive relationship between CPI, oil price and exchange rates. The positive correlation suggest that as the Kenyan shilling appreciates (which means that the exchange rate falls) then general price levels falls and with a depreciation in the Kenyan shilling (a rise in the exchange rate) then the general price level increases.

The correlation between the interest rate and the CPI is negative, which is in line with basic macroeconomic theory which posits that an increase in inflation is as a result of an increase in the money supply with no increase in real output, this then leads to an exertion of downward pressure on interest rates. The implication is that the use of the interest rate in curtailing inflation may be an important tool.

4.4 Stationarity and Cointegration.

4.4.1 Stationarity

In order to arrive at the proper specification of the empirical model, as an important step, unit root tests need to be carried out for all of the variables. We apply Augmented Dickey Fuller (ADF) unit root test to check for stationarity. The test results reported below clearly indicate that our variables are of integrated of order one (I(1)) i.e. there is presence of a unit root among all the variables. This is a necessary condition for cointegration, as all the variables exhibit a unit root, we need to examine the existence of a cointegration relation.

Table 4: ADF results

Variable	ADF p-value
LCPI	0.5943
LOILP	0.8732
LER	0.8662
LR	0.2898

Source: gretl ADF test

H0: there is a unit root for the series, Ha: there is no unit root for the series (the series is stationary). Since the computed p-value is greater than the significance level alpha = 0.05, we fail to reject the null hypothesis in all cases, which means that each series is non-stationary.

4.4.2 Cointegration

This is an important step because if there is cointegration then we would proceed with an error correction model but if there is no cointegration we would proceed with a vector autoregressive model. If the series under examination are integrated of the same order I(k) and there is a linear combination of these series that produce a stationary series I(0), then the series are said to be cointegrated.

Engle Granger Test

The first step is to test for the presence of a unit root within each individual series then the next step is to determine the order of integration I(k) of each series, where k is determined by how many times the data should be differenced to make it stationary. For the data used in this paper each individual series is integrated of order 1 due to the fact that the first differenced series of each variable is stationary.

Table 5: ADF Test on first differences

Variable	ADF p-value
d_LCPI	6.895e-0.16
d_LOILP	2.054e-0.11
d_LER	7.265e-0.10
d_LR	2.055e-0.19

Source: gretl ADF test

H0: there is a unit root for the series, Ha: there is no unit root for the series (the series is stationary). Since the computed p-value is less than the significance level alpha = 0.05, we reject the null hypothesis in all cases, which means that each series is stationary.

The third step is to estimate the cointegrating regression and finally determine if the residuals from the cointegrating regression are stationary. If the residuals are stationary then there exists at least one cointegrating relationship among the variables but if the residuals are non-stationary then there is no cointegrating relationship among the variables. The results from our data show that the residuals are non-stationary which means that there is no cointegrating relationship between the variables. This means that the relationship among the variables is best explained by a Vector Autoregressive model.

Table 6: Cointegrating regression residuals test for stationarity

Variable	ADF p-value
Residuals from the cointegrating regression	0.3481

Source: gretl ADF test

H0: there is a unit root for the series, Ha: there is no unit root for the series (the series is stationary). Since the computed p-value is greater than the significance level alpha = 0.05, we fail to reject the null hypothesis, which means that the series is non-stationary.

4.5 Vector Autoregressive Model

The first step is to select the appropriate number of lags to include within the model. This is easily done using gretl software.

4.5.1 VAR Lag Selection and Estimation

Table 7: VAR Lag Selection

The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

Lags	Loglik	p (LR)	AIC	BIC	HQC
1	2069.59831		-21.349982	-21.010660	-21.212554
2	2114.04648	0.00000	-21.646318*	-21.035537*	-21.398947*
3	2126.96119	0.05648	-21.614179	-20.731941	-21.256866
4	2141.79363	0.01982	-21.602017	-20.448321	-21.134761
5	2147.59114	0.77136	-21.495741	-20.070587	-20.918543
6	2153.44414	0.76396	-21.390043	-19.693431	-20.702903
7	2168.36826	0.01881	-21.378836	-19.410766	-20.581753
8	2177.97687	0.25756	-21.312259	-19.072731	-20.405234
9	2188.62229	0.16760	-21.256482	-18.745496	-20.239514
10	2197.03995	0.39633	-21.177499	-18.395056	-20.050589
11	2207.94471	0.14945	-21.124424	-18.070522	-19.887571
12	2230.28303	0.00016	-21.190448	-17.865088	-19.843653

The results show that for our data the best number of lags to use in our model is two.

The next step is to estimate the vector autoregression model and run the diagnostic checks first before accepting the results generated by the model.

The vector regression model is run on the first differences of the variables because the model requires that the inputs be stationary.

The model generates a separate set of equations for each variable because each variable enters the model as an endogenous variable.

4.5.2 Diagnostic check

Test of autocorrelation

Null hypothesis: no autocorrelation

Alternate hypothesis: presence of autocorrelation

Table 8: Test of autocorrelation

Equation	Dependent variable	Chi –square statistic
Equation 1	d_LCPI	0.136
Equation 2	d_LOILP	0.229
Equation 3	d_LER	0.966
Equation 4	d_LR	0.601

From the results above, since the chi-square statistic for each series is greater than the significance level alpha = 0.05, we fail to reject the null hypothesis. This means that there is no autocorrelation within the whole model. Absence of autocorrelation means that we have consistent estimators because our data is independently distributed.

Test of heteroscedasticity

Null hypothesis: no ARCH (autoregressive conditional heteroscedasticity)

Alternate hypothesis: ARCH present

Table 9: Test of heteroscedasticity

Equation	Dependent variable	p-value
Equation 1	d_LCPI	0.472041
Equation 2	d_LOILP	0.670896
Equation 3	d_LER	0.0422425
Equation 4	d_LR	0.9333784

From the results above, since the computed p-value is greater than the significance level alpha = 0.05, in Equation 1, Equation 2 and Equation 4 we fail to reject the null hypothesis. For equation 3 since the computed p-value is greater than the significance level alpha = 0.01, we fail to reject the null hypothesis at the 1% significance level. Absence of heteroscedasticity, implies conditional homoscedasticity, which enables us to make valid inferences from the results.

Test of normality of residuals

Null hypothesis: no normality

Alternate hypothesis: normality present

Table 10: Test of Normality

Variable	p-value
Residuals from the VAR regression	0.0325167

From the results above, since the computed p-value is greater than the significance level alpha = 0.01, we fail to reject the null hypothesis at the 1% significance level.

4.5.3 The VAR Model

Having passed all the diagnostic checks above, confirms that the model below is statistically fit in representing the relationship between the dependent variable current inflation and the independent variables oil price, previous inflation, exchange rates and interest rates.

Equation 1: d_LCPI

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Const	0.00446906	0.000819237	5.4551	<0.0001	***
d_LCPI_1	0.460714	0.0703948	6.5447	<0.0001	***
d_LCPI_2	−0.149453	0.0699114	−2.1377	0.0338	**
d_LOILP_1	0.000937974	0.00806653	0.1163	0.0307	

d_LOILP_2	0.0151277	0.00797228	1.8975	0.0493	
d_LER_1	−0.0292923	0.0360249	−0.8131	0.4172	
d_LER_2	0.0579382	0.0360971	1.6051	0.1101	
d_LR_1	0.0189935	0.0210774	0.9011	0.3686	
d_LR_2	−0.00143473	0.0209392	−0.0685	0.9454	

Mean dependent var	0.006594		S.D. dependent var	0.009992
Sum squared resid	0.015642		S.E. of regression	0.009026
R-squared	0.216700		Adjusted R-squared	0.184062
F (8, 192)	6.639586		P-value(F)	1.17e-07
Rho	−0.034738		Durbin-Watson	2.060380

F-tests of zero restrictions:

All lags of d_LCPI F (2, 192) = 21.562 [0.0000]

All lags of d_LOILP F (2, 192) = 2.0108 [0.0136]

All lags of d_LER F (2, 192) = 1.3359 [0.2653]

All lags of d_LR F (2, 192) = 0.40852 [0.6652]

All vars, lag 2 F (4, 192) = 2.8685 [0.0244]

Equation 2: d_LOILP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Const	0.00138757	0.00730347	0.1900	0.8495	
d_LCPI_1	−0.395013	0.627568	−0.6294	0.5298	
d_LCPI_2	1.00318	0.623258	1.6096	0.1091	

d_LOILP_1	0.224702	0.0719128	3.1246	0.0021	***
d_LOILP_2	0.0390328	0.0710726	0.5492	0.5835	
d_LER_1	−0.650304	0.321161	−2.0249	0.0443	**
d_LER_2	−0.720287	0.321805	−2.2383	0.0264	**
d_LR_1	−0.0763619	0.187904	−0.4064	0.6849	
d_LR_2	−0.230529	0.186673	−1.2349	0.2184	

Mean dependent var	0.005011		S.D. dependent var	0.085272
Sum squared resid	1.243179		S.E. of regression	0.080467
R-squared	0.145143		Adjusted R-squared	0.109524
F (8, 192)	4.074862		P-value(F)	0.000167
Rho	−0.003421		Durbin-Watson	1.975680

F-tests of zero restrictions:

All lags of d_LCPI F (2, 192) = 1.2956 [0.2761]

All lags of d_LOILP F (2, 192) = 5.9179 [0.0032]

All lags of d_LER F (2, 192) = 6.7333 [0.0015]

All lags of d_LR F (2, 192) = 0.94449 [0.3907]

All vars, lag 2 F (4, 192) = 2.1781 [0.0729]

Equation 3: d_LER

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Const	−0.000108026	0.00164675	−0.0656	0.9478	

d_LCPI_1	0.168912	0.141501	1.1937	0.2341	
d_LCPI_2	0.00990814	0.140529	0.0705	0.9439	
d_LOILP_1	−0.0232606	0.0162146	−1.4346	0.1530	
d_LOILP_2	0.000707904	0.0160251	0.0442	0.9648	
d_LER_1	0.324298	0.0724139	4.4784	<0.0001	***
d_LER_2	−0.186848	0.0725591	−2.5751	0.0108	**
d_LR_1	−0.0562289	0.0423677	−1.3272	0.1860	
d_LR_2	−0.0792739	0.0420901	−1.8834	0.0612	*

Mean dependent var	0.001574		S.D. dependent var	0.019377
Sum squared resid	0.063202		S.E. of regression	0.018143
R-squared	0.158358		Adjusted R-squared	0.123290
F (8, 192)	4.515690		P-value(F)	0.000048
Rho	0.008554		Durbin-Watson	1.982854

F-tests of zero restrictions:

All lags of d_LCPI F (2, 192) = 0.89326 [0.4110]

All lags of d_LOILP F (2, 192) = 1.0914 [0.3378]

All lags of d_LER F (2, 192) = 10.732 [0.0000]

All lags of d_LR F (2, 192) = 3.1117 [0.0468]

All vars, lag 2 F (4, 192) = 2.2091 [0.0695]

Equation 4: d_LR

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	

Const	−0.00168984	0.00278209	−0.6074	0.5443	
d_LCPI_1	−0.0968378	0.239058	−0.4051	0.6859	
d_LCPI_2	−0.0364081	0.237416	−0.1534	0.8783	
d_LOILP_1	−0.0405585	0.0273936	−1.4806	0.1404	
d_LOILP_2	0.0681493	0.0270735	2.5172	0.0126	**
d_LER_1	0.286879	0.122339	2.3450	0.0201	**
d_LER_2	0.0929759	0.122584	0.7585	0.4491	
d_LR_1	0.1934	0.0715778	2.7020	0.0075	***
d_LR_2	0.130079	0.0711087	1.8293	0.0689	*

Mean dependent var	−0.002754		S.D. dependent var	0.031832
Sum squared resid	0.180392		S.E. of regression	0.030652
R-squared	0.109864		Adjusted R-squared	0.072775
F (8, 192)	2.962181		P-value(F)	0.003787
Rho	−0.015737		Durbin-Watson	2.030290

F-tests of zero restrictions:

All lags of d_LCPI F (2, 192) = 0.1417 [0.8680]

All lags of d_LOILP F (2, 192) = 3.5179 [0.0316]

All lags of d_LER F (2, 192) = 4.0388 [0.0191]

All lags of d_LR F (2, 192) = 6.2296 [0.0024]

All vars, lag 2 F (4, 19 2) = 2.3475 [0.0559]

For the system as a whole

Null hypothesis: the longest lag is 1

Alternative hypothesis: the longest lag is 2

Likelihood ratio test: Chi-square (16) = 37.687 [0.0017]

Recall we had set out to answer the following research questions: Do oil price changes generate inflation? If so, how does inflation respond? And what is the magnitude of the response?

In the results above the relevant values are the coefficient values in each equation, which show the magnitude with which the independent variable affects the dependent variable. From the main equation, that being equation 1 we can infer that the 1 month lagged and 2 month lagged values of inflation and oil have a significant relationship with the current level of inflation.

From the estimated results, it is evident that the lagged responses of inflation rates to oil price changes are larger than the current responses. This is shown by the coefficient value 0.0151277 of the second month lag which is larger than the coefficient value 0.000937974 of the first month lag. This means that the effect of the oil price change gradually appears in the economy's inflation as time passes by and that within the Kenyan economy even though there is a significant and positive relationship between the international oil prices and inflation, the response to a positive international oil price change is not immediately absorbed into the economy's inflation, but starts to become apparent in the inflation rate at a lagged interval of two months.

The second objective of this research paper was to determine whether the asymmetric response behavior exists in the sample period. According to Lee B (2011) and Kpogli (2014) the asymmetric response behavior is based on the presence of a cointegrating relationship between oil prices and the domestic price level. The data used in this paper shows there is no cointegrating relationship between oil prices and inflation and due to the lack of a cointegrating relationship even though the effect of an increase in oil price on inflation could be greater than the effect when the oil price decreases, the difference appears insignificant.

4.5.4 Granger Causality

We aim to decide whether the independent variables cause the dependent variable, by examining how much of the current dependent variable can be explained by past values of the dependent variable, lagged values of the independent variables and to see whether adding lagged values of the independent variables can improve the explanation

The dependent variable is said to be Granger-caused by the independent variable, if the independent variable helps in the prediction of the dependent variable, or equivalently if the coefficients on the lagged independent variables are statistically jointly significant (using the F statistic).

It is possible to have one-way causation: only the independent variables Granger causes the dependent variable or only the dependent variable Granger causes the independent variable, but also two-way causation is frequently the case; the independent variable Granger causes the dependent variable and the dependent variable Granger causes the independent variable.

The results of the F statistic are shown in the VAR model estimate output above, under the title F-tests of zero restrictions. For each equation, the:

Null hypothesis: The independent variable does not granger cause the dependent variable.

Alternate hypothesis: The independent variable granger causes the dependent variable.

Equation 1: dependent variable = d_LCPI

F-tests of zero restrictions:

All lags of d_LCPI F (2, 192) = 21.562 [0.0000]

All lags of d_LOILP F (2, 192) = 2.0108 [0.0136]

All lags of d_LER F (2, 192) = 1.3359 [0.2653]

All lags of d_LR F (2, 192) = 0.40852 [0.6652]

All vars, lag 2 F (4, 192) = 2.8685 [0.0244]

The main interest of this paper is to check the relationship between oil and inflation while controlling for interest rates and exchange rates. We reject the null hypothesis if the computed p-value (the value in brackets) is less than the significance level alpha = 0.05. From the results of the main equation as presented above we can observe that there is one way Granger Causality between

- all lags of inflation and current level of inflation
- all lags of oil price and current inflation
- all lags of the equation as a whole and current inflation

Whereby we can infer that the first variable mentioned above helps in the prediction of the second variable mentioned above i.e. all lags of inflation, all lags of oil price and all lags of the equation as a whole help in the prediction of the current level of inflation.

Equation 2: dependent variable d_LOILP

All lags of d_LER $F(2, 192) = 6.7333$ [0.0015]

The results also show that all lags of the exchange rate help in prediction of the oil price. This implies that oil price also Granger-caused domestic prices indirectly through the exchange rate; that is, as oil price increases, this increases import prices and hence domestic prices.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A vast volume of past research has examined the macroeconomic response to oil price shocks with a particular emphasis on real economic activity. Relatively few analyses have tackled the related question of the effect of oil prices on inflation rates. The purpose of this paper is to examine the relationship between real oil price changes and the inflation in the framework.

This paper supports the following findings:

1. There is a positive correlation relationship between the oil price and the consumer price index but no long run cointegrating relationship between the oil price and the consumer price index. Similarly, exchange rate was found to be positively correlated to domestic price level.
2. It was observed that, due to the absence of a cointegrating relationship between oil prices and inflation, even though the effect of an increase in oil price on inflation could possibly be greater than the effect when the oil price decreases, the difference is deemed to be insignificant. This latest result implies that there is not sufficient evidence for an asymmetric relationship between an increase and a decrease in oil price, on the one hand, and domestic inflation, on the other.
3. There was also causality due to both direct and indirect effects between oil price change and inflation. The study found that oil price had a uni-directional effect on domestic prices. Oil price also Granger-caused domestic prices indirectly through the exchange rate; that is, as oil price increases, this increases import prices and hence domestic prices.

5.2 Policy Recommendations

From the conclusions of the study, it is obvious that there are effects of oil price changes on inflation. The following recommendations are made for policy consideration.

1. Since there is a positive relationship between international oil price changes and domestic price inflation in Kenya, it is recommended that government should subsidize kerosene, for instance, so as to relieve the poor from inflationary pressures during a period of increases in the oil price.
2. One of the channels through which oil price changes affect inflation is through the exchange rate; therefore, government and the monetary authorities in Kenya should strive to achieve a stable exchange rate.

5.3 Limitations of the study.

Inflation can be affected by numerous other factors which this paper does not control for, for instance weather, Kenya is a country that heavily relies on the agricultural sector, both large scale and subsistence agriculture, and crop yields are heavily reliant on weather, so the amount of output in the agricultural sector is dependent on the weather. An abundance in agricultural output will exert downward pressure on the domestic price level because there is a greater supply of agricultural output, and a reduction in agricultural output will exert an upward pressure on the domestic price level because there is less supply of agricultural output.

LIST OF TABLES

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