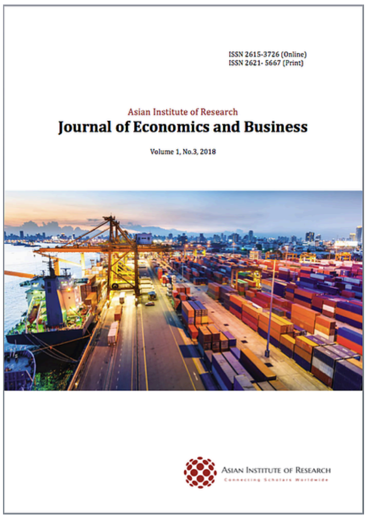

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Effect of Crude Oil Prices on GDP Growth and Selected Macroeconomic Variables in Kenya

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Abstract
Crude oil is one of the primary drivers of economic growth and a key ingredient to sustainable development. It is therefore vital that oil products be efficiently and competitively priced to accelerate economic growth. Realization of a 10% GDP growth in Kenya by the year 2030 requires a massive development in the energy sector. This study empirically explored the effect of crude oil on GDP growth and selected macroeconomic variables in Kenya; by investigating how crude oil prices affect GDP growth, Inflation and Real exchange rate. Literature has presented these three variables as the leading indicators of economic health and key variables affected by crude oil prices. Statistics from the World Development Indicator show that demand for oil in Kenya has been progressively increasing since the 1970s and this is expected to grow even further from the current consumption of 4.2 million Metric tons per year to 12 million Metric tons by the year 2030. The forecasted rise in demand has been attributed to the achievement and sustainability of the desired 10% economic growth, as envisioned in the national vision 2030 blueprint. The study used time series data covering the period 1970 to 2016, which to capture different oil shocks that have been shown through empirical and theoretical literature to have had an impact on the economy. The study estimated three Autoregressive Distributed Lag (ARDL) models to analyze the effect of crude oil on the selected variables in the study. The findings of the study revealed that Crude Oil Prices have a positive long-run impact on GDP growth, the study attributes this to the fact that Kenya imports oil and re-exports it to Uganda, Rwanda, and South Sudan. The findings also established that Crude Oil Prices have a positive effect on inflation in the long run, while in the short run its lag of one affect inflation, meaning that the Crude oil prices for the previous one year affect the current year's inflation rate. The relationship between crude oil prices and Real Exchange Rate was negative in the long run.

Key Words: Oil Prices, ARDL, GDP Growth, Kenya

1. Introduction

There exist limited indigenous energy resources in Kenya, and there is a concern that it may not be sufficient in sustaining the Country's economic development in the long run and may thus drive the Country into relying on energy imports (Macharia, 2017). Currently, Kenya meets 60 percent of its total energy demand through imports. National oil (2016) projects the share of imported energy to increase by 10 percent as a result of oil consumption by the Standard Gauge railway and reviving of industries that had collapsed such as Webuye pan paper mills; various irrigation schemes; urbanization that has led to increase in public service transportation and massive importation of cars by Kenyans etc. The challenge, therefore, is to secure adequate oil supplies at the minimum possible cost.

Demand for oil has been on the rise over the years, and this is expected to rise even further. Meeting soaring demand of crude oil and realization of most of the goals and aspirations in the vision 2030 blueprint calls for massive development in the energy sector. The National Oil (2016) estimates that at the economic growth rate of 10% desired to achieve Vision 2030, petroleum and gas consumption will grow from the current 4.5 million MT to 12 million MT by 2030.

Oil is widely used across all sectors of Kenya's economy, especially in manufacturing, transportation, and power producing industries. However, the price dynamics of oil have been relatively volatile in the recent years, posing a threat to the various sectors and the overall economy. Kenya suffers from a shortage of internal energy resources, including oil (National oil, 2016); as a result, Kenya continues to be in the category of net oil importing developing countries; this subjects the economy to vulnerability to external shocks, notably oil price fluctuations, exposing the country to risks associated with oil prices. Marquez (1986) notes that for a non-OPEC developing nation such as Kenya, oil price risk includes: a reduction in aggregate demand, increase in consumption price deflator and a decline in real income.

It is against this backdrop coupled with a lack of an effective cost-beneficial substitute available that this study sought to examine whether the prevailing hypothesis as propagated by Hamilton (1983) that oil price fluctuations hurt a net oil importing country's macroeconomic performance holds for Kenya. The endogenous variables used as proxies for macroeconomic performance are GDP growth, real exchange rate, and inflation level. The choice of variables is primarily informed by a study by Marquez (1986)) which is used as a benchmark. Moreover, according to Cologni & Manera (2008), these three variables are presented as the leading indicators of an economy's health. This study contrasts other studies carried out on Kenya's data, as it estimates the variables in a system framework, this addresses the shortcomings of non-coexistence bias and allows for a lagged and contemporaneous interconnection among the variables under study including control variables. The approach also enabled the study to measure the long run and short run effects making it possible to determine whether the impact of oil prices on GDP growth and the selected macroeconomic variable is temporary or permanent.

2. Literature Review

Empirical research on the relationship between oil prices and GDP growth focusing on developing countries especially in sub-Saharan Africa are few as much focus has been placed on developed nations (Chuku *et al*. 2010). There is an existence of little and scanty empirical literature on emerging oil-producing countries such as Kenya, and how the discovery of oil is going to change the shape of the economy. There is no direct relationship between economic growth and crude oil prices, the relationship between the two variables is mostly dependent on a country's macroeconomic policy, institutional frameworks and sectoral structure (Chuku *et al*. 2010).

Many studies have focused on developed countries for example (Hamilton J. D., 1983: 1996: 2010; Rodrigues & Sanchez 2005; Filis & Chatziantoniou 2013). Findings of the studies reveal that there is an inverse relationship between crude oil prices and GDP growth. The studies also point out that crude oil prices negatively affect the manufacturing sector leading to reduced production of industrial goods. The common conclusion, however, is that the relationship is not steady for the countries over time. This conclusion was further confirmed by Blanchard & Gali (2007), in their comparison of how oil prices affect inflation and GDP growth in the contemporary economies vis-a- vis those in the 1970s. The study established that the unsteady relationship is rampant in the modern economies as compared to the ones in the 1970's, they attributed this to a more flexible labor market, lower energy intensity and stable monetary policy.

Studies on the effect of crude oil prices on GDP growth have also produced varying results. In a survey of oil fluctuations and its impact on the GDP of Singapore Chang & Wong (2003), findings revealed that there an adverse effect although the effect is not significant. The results also showed that there is an insignificant inverse relationship between crude oil prices and other variables under study notably inflation and unemployment rate.

The study is however contradicted by a study conducted on Iranian economy by Farzanegan & Markwardt

(2009) and on Nigerian economy by Oriakhi & Osaze (2013). By using correlation analysis, the studies established a positive relationship between the two variables. The findings are attributable to Nigeria and Iran being oil exporting nations.

Jumah & Pastuszyn (2007) while using cointegration analysis on time series data covering 1965-2004, estimated the impact of oil price shocks on GDP growth through the interest rate channel. The study, however, failed to establish a significant relationship between the two variables. Nevertheless, the study identified that there is a positive relationship between crude oil and price levels which sequentially affects negative output negatively in the long run.

In a similar study and by utilizing Vector Error correction model, Adam (2008) attempted to estimate the short-run and long-run effect of crude oil prices on selected macroeconomic variables namely exchange rate, GDP, Interest rate and inflation in Ghana. The study used data covering 1970:1 to 2006:4 and the finding of the study were that the effect of crude oil on inflation level was positive while that on output was negative.

Focusing on studies in Kenya, Mureithi (2014) on his research on oil import volatility and its effect on economic growth in Kenya revealed that Oil import volatility has a significant adverse impact on GDP growth both in the short- run and the long-run. However, most research suggests that an increase in oil import results in increased economic growth and vice versa. Using Johansen-Juselius approach to co-integration test and vector error correction, the author could only establish one cointegrating relationship among the four variables under study (real exchange rate, traffic volume, total manufacturing index, and GDP growth rate).

The empirical studies on the impact of crude oil prices on inflation have produced mixed results. Odera (2015) researched on the relationship between international diesel price and the inflation rate in Kenya. The study adopted secondary time series data co-integration test to determine the long-run equilibrium relationship when the series has a linear combination and Granger causality test to test the short-run relationship between dependent and independent variables. The correlation matrix and regression failed to find the perfect link between the variables and Granger causality test also confirms that there is no short-term relationship; the study concludes that the hike in international diesel oil price does influence the domestic inflation rate as suggested by monthly data of variables.

Metcalf & Wolfram (2010), found that political stability is one of the main contributors to oil production volatility in OPEC countries. Countries with very democratic political systems had less volatility in oil production than their counterparts with autocratic political regimes. Fluctuations in oil production were found to affect global oil prices, thereby causing price volatility in countries that import oil. Besides, the level of oil consumption and the size of the economy determined oil import volatility. These results were based on data collected from OPEC and OECD countries. The dataset included oil production levels, oil import volumes, GDP, and the composite democracy index for the period 1970-2007. The study utilized two-stage least squares econometric method for data analysis. However, the researchers failed to consider the possible causes of oil import volatility in the context of developing countries such as Kenya that heavily rely on oil as their primary source of energy.

In a study on Pakistan's Economy, Naveed (2010) attempted to measure the effect of changes in oil prices on government expenditure, consumption and real exchange rate, inflation and GDP growth using annual data from 1972- 2009. By examining the long run, and short run effect, the finding revealed that there is an existence of a short-run and a long-run negative relationship between inflation and all the other variables apart from GDP. Results on GDP shows that the impact of oil is detrimental in the long run but positive in the short-run. This study, may not be however comparable to Kenya due to the difference in the level of economic development between Kenya and Pakistan.

Arinze (2011) while attempting to studying the impact of oil price on Nigerian economy using data from 1978-2009 and using the hypothesis approach, the study established that there is a direct and significant relationship between prices of petroleum products and inflation. Similar research by Eregha, Mesaran & Ayoola (2015) using data from 1994-2012 in Nigerian economy also reveals that there is a positive effect of oil prices on inflation in the long run however in the short-run the relationship is not significant.

Tang & Xiong (2011) found a positive correlation between oil price speculation and prices of other commodities their study is consistent with Juvenal & Petrella (2012) study on oil price speculation established that oil prices have a positive impact on inflation, they further concluded that an expansion of the economy calls for an increase in demand for raw material such as oil, it is this demand that then increases prices of commodities.

Irwin & Sanders, (2010) however, contend the role of speculation in oil pricing and commodity pricing, their study did not show any changes in prices of oil as a result of speculation and hence no change in the inventory prices or level.

Studies in Kenya have shown mixed results, Odera (2013) in a study on the relationship between diesel price and the inflation rate in Kenya found that there is a positive correlation between the two variables although it is weak and insignificant. Using Vector Error Correction and Johannsen Cointegration approach on quarterly data during the period 1996Q1-2011Q4, (Suleiman, 2013) found a strong and positive correlation in the short run, the relationship was however not significant in the long-run.

Many of the studies on the relationship between real exchange rate and oil prices have mainly concentrated on effective exchange rates. It is, however, worth noting that there are different findings across the studies and regions. Kilian &Taylor (2003) point out that there are many nonlinearities between oil prices and nominal exchange rate. The relationship can only be linear in the event of high inflation differentials which lead to a more relative Purchasing power parity in the long run.

The findings were contradicted by Habib & Kalamova (2007) on their study on the role of oil exchange rate movements. They used Vector Error Correction on data from Russia, Norway, and Saudi Arabia's economies and only found a long run relationship between oil prices and exchange rate exists in Russia but not Norway and Saudi Arabia. The study agrees with the findings by Al-Mulali (2010) which established that there is a real long-run appreciation of effective exchange rate in Norway as a result of an increase in oil prices.

Recent studies reveal that there is no clear connection between real exchange rate and price of oil both in oil-importing and exporting countries. Buetzer *et al*., (2016) while using Structural VAR analysis to study oil price shocks for a group of 43 countries reports that there is no indication of appreciation of exchange rate of oil exporters against those of oil importers. The lost connection might be attributable to the intervention measures in the foreign exchange rate market by the higher oil surplus economies.

This results closely agree with Beckmann & Czudaj (2013) analysis on within and between effect estimation of a set of 10 countries. They reveal that the results vary not only within but also between the groups of oil importing and exporting countries.

2.1 Theoretical Model

The economic theory underpinning this study stems from the *Marquez model*. This model was developed by Jaime Marquez in 1986 while advancing the works of Metzler (1950) on transmission channels of oil prices internationally. Marquez, formulated a three region-three goods model of the world economy to highlight the channels by which the exogenous increase in the price of oil is internationally transmitted.

The theory puts across the effect of changes in oil prices in three country blocks: developed economies, OPEC economies and non-OPEC developing economies. For this study, we are going to concentrate on the theorem's analysis on non-OPEC developing economies.

The theory posits that oil prices impact real income in non-OPEC developing countries through various channels. The theory points out the first channel to be its negative impact on consumption by causing an increase in consumption price deflator. An increase in consumption price deflator reduces real income and causes inflation. The other channel through which real income is affected is as a result of the impact of oil prices on the nominal holdings of foreign exchange reserve and their real purchasing power, which is caused by the increase in the export price of manufacturers in developed countries, resulting to high import prices and a decline of foreign real exchange rate reserve in developing economies. The decline in the real exchange rate reserve in turn adversely affects the import of manufacturers, capital formation and capital stock in the non-OPEC developing country which further dampens output growth and increases the prices of commodities.

Using mathematical notations and equations, Marquez model posits that oil prices would result to foreign exchange constraint on imports of manufacturers in non-OPEC developing countries. Oil payments are thus deducted from the computation of foreign exchange resources, assuming that these countries use whatever is left to finance imports of manufacturers. This is shown in equation 1

$$M_m = (R + P_r M_r - P_O M_O)/P_m \qquad (1)$$

If foreign exchange constraints are binding, then imports of manufacturers will be limited, dampening capital accumulation, reduction of output leading to low-income growth and inflation. Finally, oil imports are determined as a function of oil prices and real income; this is shown in equation 2

$$M_O = M_O(P_0, Y) \qquad (2)$$

Where:
Y – Real income
O - Oil
R - Resource transfer
r – Raw material
M - Imports
m - Manufacturing

3. Methodology

The study was specified in three models, one that shows the relationship between oil prices and GDP growth, the other that shows the relationship between oil prices and inflation and another one that shows the relationship between oil prices and real exchange rate. These models are informed by the theoretical underpinnings that stem from the study by Marquez (1986).

The models are specified using ARDL procedure as developed by Pesaran, Shin & Smith (2001) to examine the short- run and long-run relationship between oil prices and the three variables; we employ the ARDL procedure. The ARDL cointegration approach has numerous advantages in comparison with other econometric methods: the underlying regressors are not restrictive irrespective of whether the variables are integrated of order zero or one, i.e., I (0) or I (1). Bahmani-Oskooee & Ratha (2004) stated that the uncertain results from different tests are dependent on the power of

unit root tests. To overcome this problem, the ARDL-bounds testing approach does not require the classification of variables into stationary and nonstationary. Secondly, it is suitable for any sample size, be it small or large. Thirdly, this approach provides unbiased estimates of the long-run model and valid *t*-statistics even when some of the regressors are endogenous.

Model one

Given equation 2 which premises that oil import is a function of oil prices and real income. However, to meet our objectives of the effect of oil prices on GDP growth, the model will be modified to by making real income the subject of the formulae as shown in equation 3.

$$Y = f(-P_O, M_O) \qquad (3)$$

Equation 3 shows that real income is an increasing function of oil imports and a decreasing function of oil prices. The influence of crude oil price on the real GDP growth rates of Kenya's economy will be determined by fitting the following regression equation.

$$\Delta GDP_t = \beta_0 + \beta_1 COP_1 + \beta_2 OI_2 + \varepsilon_t \qquad (4)$$

Where

ΔGDP_t denotes the real GDP growth

β_0 the intercept of the line on Y- axis.

β_1 and β_2 denotes the slope coefficient

COP_1 denotes the crude oil price. (Yearly Kenyan basket price).

OI_2 denotes oil imports

ε_t is residual term of the model representing all other factors that influence GDP growth that has not been included in the model.

Since the study sought to test for both the short-run and long-run relationship between the variables, The Autoregressive Distributed Lag model (ARDL) was estimated. The method has been used since 2001 after it was developed by Pesaran, Shin and Smith to model the relationship between Economic variables in a single equation time series variable. ARDL has also gained popularity due to making cointegration of nonstationary variables equal to an Error-Correction process. Additionally, the model has a reparameterization in the Error-Correction form (Hassler, 2000).

According to Pesaran, Shin, & Smith (2001), the Error-Correction presentation is also vital for testing for the existence of the long-run relationship. The bounds testing procedure is useful for drawing conclusive evidence without considering whether the variables are stationary at level (Integrated of order zero) or at first difference (Integrated of order one).

Model 4 will, therefore, be reparametrized into the ARDL framework as follows:

$$\Delta GDP = \alpha_0 + \sum_{j=1}^{n} b_j \Delta GDP_{t-j} + \sum_{j=0}^{n} c_j \Delta COP_{t-j} + \sum_{j=0}^{n} d_j \Delta OI_{t-j} + \delta_1 GDP_{t-1} + \delta_2 COP_{t-1} + \delta_3 OI_{t-1} + \varepsilon_{1t} \qquad (5)$$

Where:

Δ denotes the first difference operator. The parameters δ_i, i=1,2,3 function as the long-run multipliers, while the b_j, c_j and d_j function as the short-run dynamic coefficients of the underlying ARDL model.

Model two

From Marquez model equation 1, an increase in the price of oil can be translated to inflation and real exchange rate through its effect in the cost of manufactured goods denoted by P_m. This dampens imports of manufactured goods in non-OPEC developing countries leading to a decline in imports of capital goods and capital accumulation, leading to low output growth and high prices of commodities. To carry out the quantification of expected influence of crude oil prices on inflation and real exchange rate, we will modify equation 1 to follow the model of Expectations-Augmented Phillips Curve, 1968, as developed by Milton Friedman and Edmund Phelps which is depicted as follows:

$$INF = \beta_0 + \beta_1 COP_t + \beta_2 FR_t + \beta_3 RER_t + \varepsilon_t \qquad (6)$$

Where

INF denotes the inflation rate

COP denotes Crude oil prices
FR_2 denotes Foreign remittances
RER_3 denotes Real exchange rate
ε_t is residual term of the model representing all other factors that influence GDP growth that has not been included in the model.

Crude oil prices and error terms (other factors not included in the model such as political stability, drought, national security among others) constitute cost-push inflation while real exchange rate and foreign remittances constitute demand-pull inflation (Romer, 2000).

To meet the objective of the long run and short effect of crude oil prices on inflation, the study will use an ARDL model.

$$\Delta INF = \alpha_0 + \sum_{j=1}^{n} b_j \Delta INF_{t-j} + \sum_{j=0}^{n} c_j \Delta COP_{t-j} + \sum_{j=0}^{n} d_j \Delta FR_{t-j} + \sum_{j=0}^{n} e_j RER_{t-j} + \delta_1 INF_{t-1} + \delta_2 COP_{t-1} + \delta_3 FR_{t-1} + \delta_4 RER_{t-1} + \varepsilon_{1t} \quad (7)$$

Δ denotes the first difference operator. The parameters δ_i, i=1,2,3,4 function as the long-run multipliers, while the b_j, c_j, d_j and e_j function as the short-run dynamic coefficients of the underlying ARDL model.

Model three
Marquize model posits that oil prices have an impact on the nominal holdings of foreign exchange reserve and their real purchasing power, which is caused by the increase in the export price of manufacturers in developed countries, resulting to high import prices and decline of foreign exchange rate reserve in non-OPEC developing economies.

The empirical model can be stated as:

$$RER_t = \beta_0 + \beta_1 COP_t + \beta_2 CAB_t + \varepsilon_t \quad (8)$$

Where:
RER_t denotes the real exchange rate
β_0 the intercept of the line on Y- axis.
β_1 and β_2 denotes the slope coefficient
COP_t denotes the crude oil price. (Yearly Kenyan basket price).
CAB_t denotes current account balance

The ARDL model is expressed as equation 9 below

$$\Delta RER = \alpha_0 + \sum_{j=1}^{n} b_j \Delta RER_{t-j} + \sum_{j=0}^{n} c_j \Delta COP_{t-j} + \sum_{j=0}^{n} d_j \Delta CAB_{t-j} + \delta_1 RER_{t-1} + \delta_2 COP_{t-1} + \delta_3 CAB_{t-1} + \varepsilon_{1t} \quad (9)$$

Where:

Δ denotes the first difference operator. The parameters δ_i, i=1,2,3 function as the long-run multipliers, while the b_j, c_j and d_j function as the short-run dynamic coefficients of the underlying ARDL model.

4.0 Empirical Results and Discussion

The ARDL technique was used to estimate the coefficient for both the long run and the short run. This technique has an advantage of estimating procedure which allows examination for a level relationship regardless of the order of integration of the fundamental series. But first, it is important to run the stationarity test to determine the order of integration.

Table 1: Unit root test results

Variables	**ADF Test**		**PP test**		
	At level	First Difference	At level	First Difference	**Order of Integration**
COP	-2.178	-6.267 (3) **	-2.297	-6.264 (3) **	I (1)
OI	-1.889	-6.009 (3) ***	-2.136	-6.001 (3) **	I (1)
ΔGDP	-5.423***	-11.719 (3) **	-5.630**	-11.423 (3) *	I (0)
INF	-3.957**	-7.745 (3) *	-3.935**	-8.242 (3) ***	I (0)
RER	0.375	-6.132 (3) **	0.347	-6.121 (3) **	I (1)
FR	1.1717	-5.097 (3) **	1.682	-5.078 (3) ***	I (1)
CAB	-2.502	-10.850 (3) ***	-2.316	-10.854 (3) *	I (1)

Stationary feature was analyzed using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) for unit root; the two tests are run for robustness. The bandwidths for PP test are selected with the Newey–West Bartlett kernel method. It is essential to ensure that that the order of integration of the series is either integrated of order zero I (0) or Integrated of order one I (1) (Kripfganz & Schneider, 2016). The tests were performed on each variable, and the results are presented in table 1. Results indicate that only GDP growth and Inflation were stationary in level I (0) while Crude oil prices, Oil Imports, Real Exchange Rate, Foreign Remittances and Current Account Balance had to be differenced once to become stationary, meaning that they are integrated of order zero I (0).

4.1 ARDL Bounds Test for Cointegration

After carrying out the unit root test which is essential for determining the order of integration, the next step is to determine the existence of cointegration among the variables; this was conducted using the bounds approach to integration. One key advantage of the bounds testing approach is that it establishes whether there is presence or absence of long-run relationship between the variables.

To ascertain whether cointegration is present, the F-test of joint significance of lagged levels of the variables as well as the t-test on lag level of the dependent variable in the model must reject the null hypothesis of no cointegration.

Table 2: Results of Bounds Cointegration test for model one

Test	**10%**		**5%**		**1%**		**P-value**	
	1(0)	**1(1)**	**1(0)**	**1(1)**	**1(0)**	**1(1)**	**1(0)**	**1(1)**
F	3.307	4.327	4.046	5.184	5.763	7.145	0.000	0.000
t	-2.575	-3.236	-2.906	-3.597	-3.568	-4.309	0.000	0.000
F = 22.664, t = -6.727								

Table 2 presents the ARDL bounds cointegration results. It displays a case 3 test, i.e.,, unrestricted intercept and no trend (Pesaran *et al*., 2009). The criteria for interpretation is to accept null (H0) if the F and t calculated tend towards zero as compared to the F and t calculated and to accept the null (H0) if F and T calculated move extremely further from zero than the critical values. The F-statistic in bounds cointegration tests the joint significance of the coefficient of the coefficients in lagged levels in ARDL-ECM whereas the t-statistic is used to test for significance of the coefficient of the of the lagged dependent variable

Results indicate that the values of F and t are extreme from zero than the critical values, at 10%, 5%, and 1%, meaning that both tests are significant. We, therefore, reject the null hypothesis of no cointegration and conclude that the equation of GDP, Crude oil prices, and Oil import exhibits a long run relationship.

Table 3: Results of Bounds Cointegration test for model two

Test	10%		5%		1%		P-value	
	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)
F	2.862	4.018	3.475	4.771	4.904	6.505	0.002	0.009
t	-2.550	-3.439	-2.890	-3.821	-3.575	-4.579	0.000	0.005
F = 6.594, t = -4.839								

The second model represents the relationship of crude oil prices on Inflation, in this case, Inflation was the dependent variable while independent variables included, Crude oil prices, Foreign Remittance and Real Exchange rate as independent variables. The results show that the F and t values are far from zero compared to the critical values, at 10%, 5%, and 1%. We, therefore, reject the null hypothesis of no cointegration and conclude that there exists a long run relationship between the dependent variable (Inflation) and the nonstationary variables (Crude oil prices, Foreign remittances and Real Exchange rate).

Table 4: Results for Bounds Cointegration test for model three

Test	10%		5%		1%		P-value	
	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)
F	3.299	4.342	4.043	5.213	5.779	7.217	0.000	0.000
t	-2.567	-3.228	-2.901	-3.594	-3.573	-4.318	0.000	0.000
F = 21.251, t = -6.500								

The third model attempts to investigate the effect of Crude oil price on Real Exchange rate; the independent variable includes Crude Oil price (COP) and current account balance (COB) while Real exchange rate (RER) is the dependent variable. The results indicate that the F and t values are far from zero at the 10%, 5% and 1% level of significance. The P-value for both tests is also zero, and therefore we reject the null hypothesis of no cointegration and further make a conclusion that there exists a long-run relationship between the dependent variable (Real exchange rate) and the independent variables; crude oil prices and current account balance.

4.2 Autoregressive Distributed Lag Results

The ARDL results for the three models are in tables 5, 6 and 7.

Table 5: Overall results for model one

	Coefficient	Std. Error	t	p>t
ADJ GDP L1	-.6768491	.100615	-6.73	0.000
		Long-Run Estimates		
COP	.0162505	.0197256	0.82	0.415
OI	7.78e-11	4.88e-10	0.16	0.874
		Short-Run Estimates		
GDP LD	.2468649	.0814425	3.03	0.004
Constant	2.132113	.8586421	2.48	0.017
		ARDL Estimates		
Model	(2, 0, 0)			
R-squared	0.5388			
Adjusted R-squared	0.4927			

Table 5 shows the ARDL results for model one; that relates GDP growth to crude oil prices and Oil imports. The study estimated an ARDL (2, 0, 0) which was selected based on AIC.

The results as shown in table 4.8 indicate that the long-run coefficient is positive, implying that crude oil prices and oil imports contribute to GDP growth. An increase in the price of crude oil by $1 would lead to a 0.016 percent. However, this coefficient not statistically significant at 5% and therefore this does not violate the economics principle. The positive coefficient can be explained by the consistent rise in petroleum re-exports over the last two decades to Uganda, South Sudan, Rwanda and the Democratic Republic of Congo.

The table also reports the short-run coefficient estimates that were generated from the Error Correction Model version of the ARDL model. The ECM is important as it gives an indication of the speed of adjustment which restores the stability of a model that is dynamic. This implies that the coefficients obtained denote the speed at which the variables in the model converge to equilibrium. The coefficients are expected to be statistically significant and should have a negative sign.

The table shows the ECM coefficient as -0.6768, this can be interpreted to mean that the error term has met the set conditions and thus it is statistically significant. The result confirms the existence of a steady long-run relationship.

The short-run results indicate a significant relationship of GDP growth when lagged implying that that higher GDP growth rate of the previous two years would tend to increase the GDP growth rate of this year from 1970-2016. The model has a coefficient of determination of 53%, meaning that 53% of the variation in GDP growth is explained by Crude Oil Prices, Oil import and GDP growth of up to the previous two years, it is generally a good fit.

Table 6: Overall Result for Model two

	Coefficient	Std. Error	t	p>t
ADJ INF L1	-.6407159	.1323982	-4.84	0.000
		Long-Run Estimates		
COP	.0486824	.057376	0.85	0.040
FR	-3.40e-09	5.81e-09	-0.59	0.562
RER	-.0584651	.0741785	-0.79	0.436
		Short-Run Estimates		
INF LD	.1780934	.1271773	1.40	0.170
COP D1	.114008	.060518	1.88	0.047
RER D1	.8616591	.1849219	4.66	0.000
Constant	6.788766	2.964019	2.29	0.028
		ARDL Estimates		
Model	(2,1,0,1)			
R-Squared	0.5793			
Adjusted R-squared	0.4997			

Table 6 provides the results of ARDL estimation of the relationship between Inflation and crude oil prices, Foreign remittance and Real Exchange rate. We estimated an ARDL (2,1,0,1) which was selected using the Akaike Information Criteria. The results show a positive coefficient between Crude Oil Price and Inflation (0.0487) which is statistically significant at 5%. This implies that an increase in crude oil price by $1 is likely to result to a 0.048 rate of inflation.

The ECM coefficient has a negative value (-0.640) and is statistically significant at 5%. This is further evidence of the existence of a Long run relationship that had been initially established using the bounds cointegration test. All the variables in the short run have positive coefficients and are all statistically significant apart from the lag of inflation. The crude oil price has a lag of two implying that if crude oil prices increased by $1 last year, it would result in an increase in the rate of inflation for this year by 0.114%.

From the result of the coefficient of determination (R^2 =57.93%), it is clear that the general goodness of fit of the estimated equations is reasonably high.

Table 7: Overall results for model three

		Coefficient	Std. Error	t	p>t
ADJ	RER L1	-.9998022	.1538199	-6.50	0.000
			Long-Run Estimates		
	COP	-.1721089	.0789592	-2.18	0.036
	CAB	8.58e-10	6.36e-10	1.35	0.185
			Short-Run Estimates		
	COP L1	.1309854	.0669158	1.96	0.058
	COP D1	.0867235	.0486901	1.78	0.083
	Constant	2.479541	.8298228	2.99	0.005
			ARDL Estimates		
	Model			(1,2,0)	
	R-squared			0.5526	
	Adjusted R-squared			0.4937	

Table 7 shows the overall result for the ARDL estimation on the relationship between Crude Oil Prices and Real exchange rate. The estimated model was an ARDL (1,2,0) which was selected using the AIC criteria.

The long-run estimates show that there exists a negative relationship between the current Account balance and Real Exchange rate. An increase in the price of Crude Oil by $1 would result in a depreciation of the Shilling by 0.172 in the long run. This coefficient is statistically significant at 5%. The adjusted ECM coefficient has a negative value (- 0.999) and is statistically significant at 5%. The result confirms the existence of a Long run relationship that had been initially established using the bounds cointegration test.

Short run results show two lags of crude oil prices, and both have a positive 0.130 and .086 for lag one and two respectively. However, the coefficients are not statistically significant at 5%. The coefficient of determination is 55.26% (R^2=0.5526) indicating that the model is a reasonably good fit.

4.2 Postestimation Diagnostic tests

Postestimation tests such as serial correlation, heteroscedasticity, and stability tests were conducted to ensure that the results were conforming to econometrics assumptions. As shown in table 8, the three models pass all the diagnostic tests; there is no evidence of serial correlation, as comfirmed by Breusch-Godfrey LM test for autocorrelation and they all have constant variances as demonstrated by LM test for autoregressive conditional heteroskedasticity (ARCH). The three models were stable according to CUSUM and CUSUMQ test; the results are shown in the appendix section.

Table 8: Post Estimation Diagnostic Tests

Postestimation test	Test statistic	Degrees of Freedom	P-value
Model one			
Ramsey rest test	F (3,37) = 0.95	-	Prob>F=0.4283
Breusch-Godfrey LM test for Autocorrelation	Chi2=0.914	1	Prob > chi2=0.3389
LM test for conditional heteroskedasticity (ARCH)	Chi2=0.935	1	Prob > chi2=0.3335
Model two			
Ramsey rest test	F (3,34) = 1.43	-	Prob>F=0.2524
Breusch-Godfrey LM test for Autocorrelation	Chi2= 0.793	1	Prob > chi2=0.3733
LM test for conditional heteroskedasticity (ARCH)	Chi2= 0.401	1	Prob > chi2= 0.5267
Model three			
Ramsey rest test	F (3, 37) = 2.38	-	Prob>F=0.0849
Breusch-Godfrey LM test for Autocorrelation	Chi2= 0.004	1	Prob > chi2= 0.9504
LM test for conditional heteroskedasticity (ARCH)	Chi2= 0.001	1	Prob > chi2= 0.9739

5.0. Conclusion

This study examined the Effect of Crude oil prices on selected macroeconomic variables namely, GDP growth, Inflation and Real Exchange Rate in Kenya. As a result, three models were estimated using an econometric method known as Autoregressive Distributed Lag (ARDL) which was recently developed by Pesaran, Shin &Smith (2001) with GDP growth, Inflation and Real exchange rate as dependent variables in the models.

The method was selected due to its ability to estimate the short run and long run relationship among the variables and still producing unbiased long-run estimates and valid *t*-statistics irrespective of whether some of the independent variables are endogenous. It is also superior to other econometric approaches as the underlying independent variables are not restrictive regardless of their order of integration, they can be either be integrated of order zero or one, i.e.,, *I* (0) or *I* (1). Thirdly, it can use any sample size and give unbiased results. The study establishes that the ARDL requirement that all the variables in the system are I (1) is satisfied.

The study revealed that Crude Oil prices have a positive long-run effect on GDP which can mainly be attributed by the fact that Kenya imports oil for resale to Uganda and the entire great lake region. This is going to be beneficial to the country now that Kenya is in the early stages of oil production and distribution through the Early Oil Pilot Scheme (EOPS). If the production of oil will be consistent, then the oil prices will result in GDP growth in the long run and possibly towards attaining the target set in the vision 2030 blueprint of 10%.

Crude Oil prices were shown to affect inflation both in the long run and in the short-run. Previous year's crude oil price was also shown to affect the current year's inflation. This is consistent with a priori where oil prices affect inflation by raising the prices of commodities which are produced using oil as an intermediate input in the production process.

Crude oil price is shown to contribute to the depreciation of the Real exchange rate in the Long run. However, the study shows no evidence of short-run relationship between the two variables. This finding conforms with existing literature, as the two variables are expected to have an inverse relationship. As the US dollar rises, the Kenyan shilling depreciates, because it costs Kenya relatively more to purchase the same amount of dollar in the foreign exchange market. A rise in the crude oil prices, therefore, widens the country's trade deficit and makes the shilling to lose value, as Kenya is a net oil Importer.

5.1 Policy Recommendation

The study recommends that the Energy Regulatory Commission (ERC) should direct much of its efforts towards promotion of eco-friendlier and cheaper energy sources such as ethanol to stop the overreliance on crude oil. Kenya enjoys a comparative advantage in the production of sugarcane and maize in the East African Community; these are the critical raw materials in the production of ethanol. This will make the price of oil reduce thus curing the inflation problem and increasing GDP growth rates.

Secondly, the nation should focus more in pursuing the manufacturing course in the "Big Four" agenda as well as adopting an export promotion strategy to lessen the pressure on the depreciating exchange rate which comes about as a result of oil importation. This will also aid the growth of the economy to a more considerable extent

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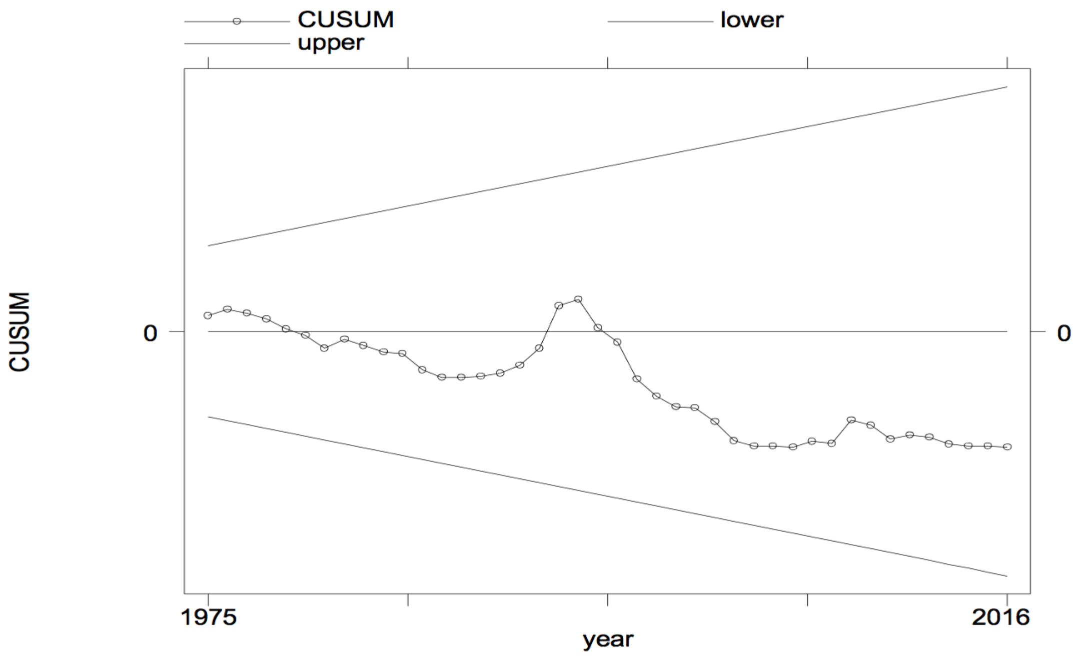
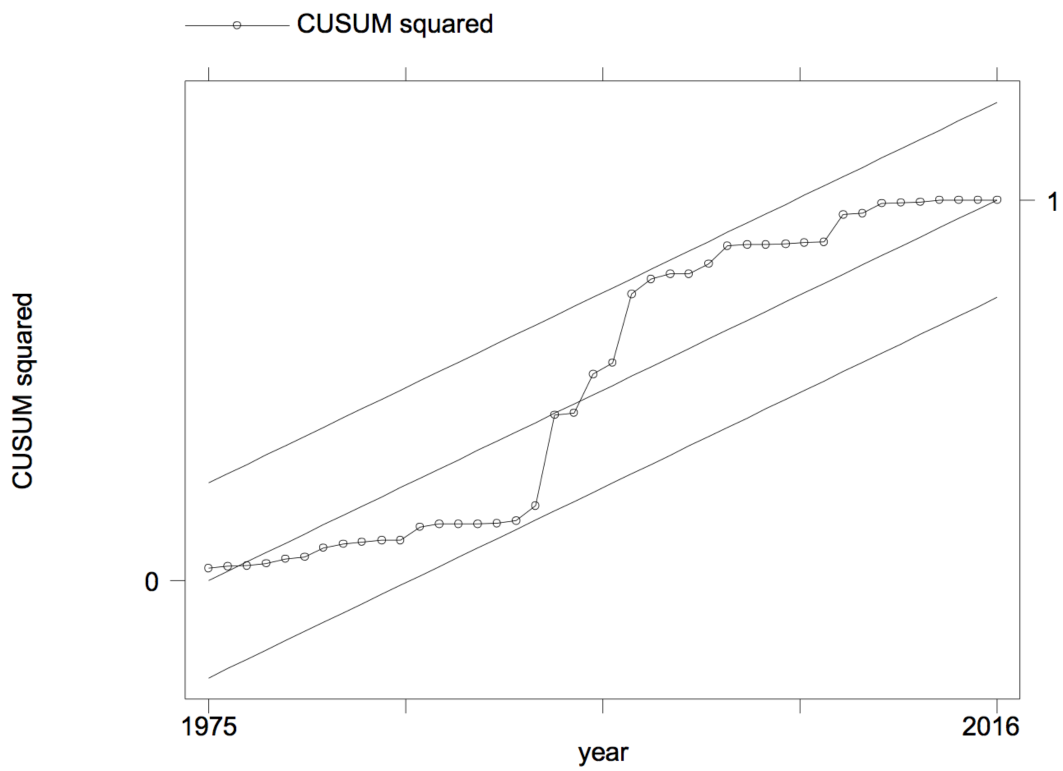
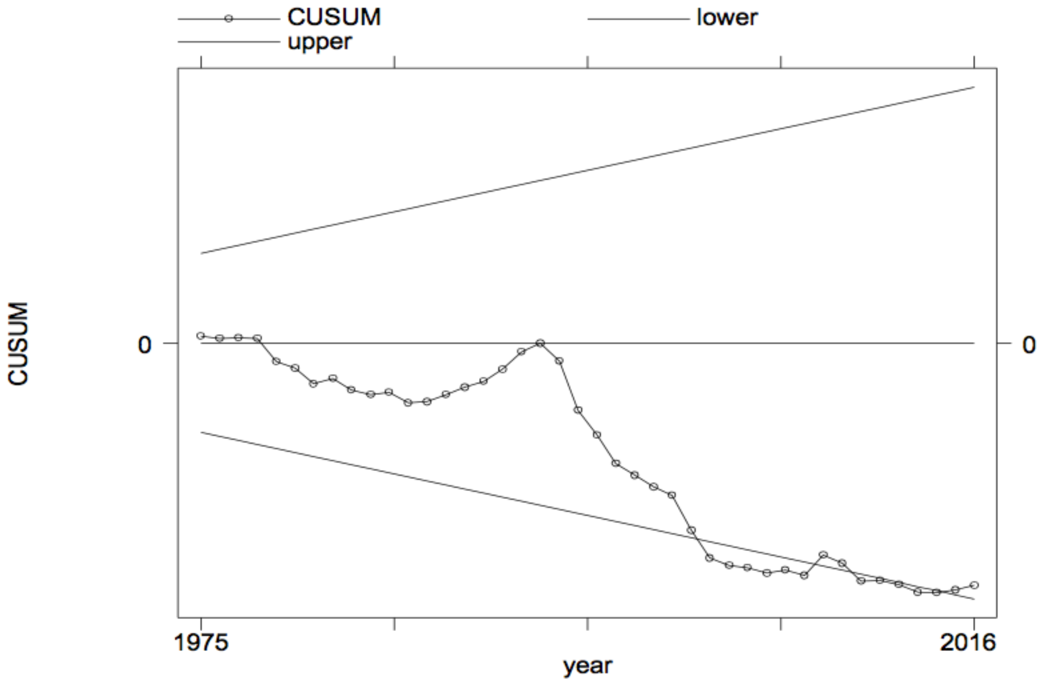
APPENDIX 1: Plot of cumulative sum and cumulative sum of squares of recursive residuals stability tests

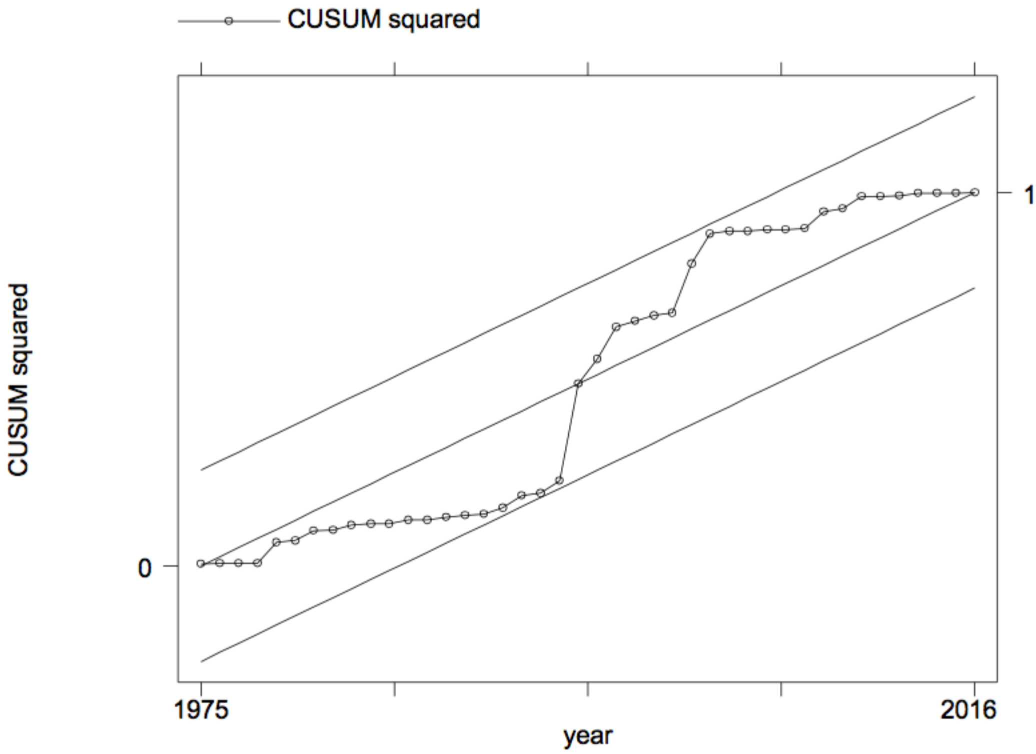
Model One



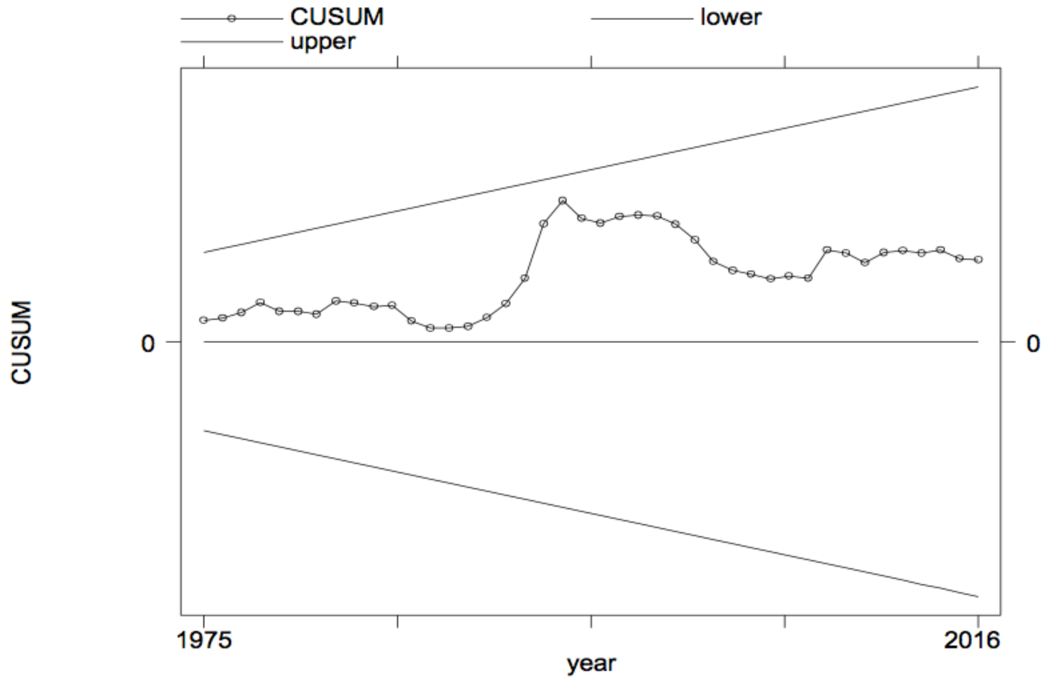


Model Two


CUSUM
lower
upper
CUSUM
0
0
1975
2016
year


CUSUM squared
CUSUM squared
1
0
1975
2016
year

Model Three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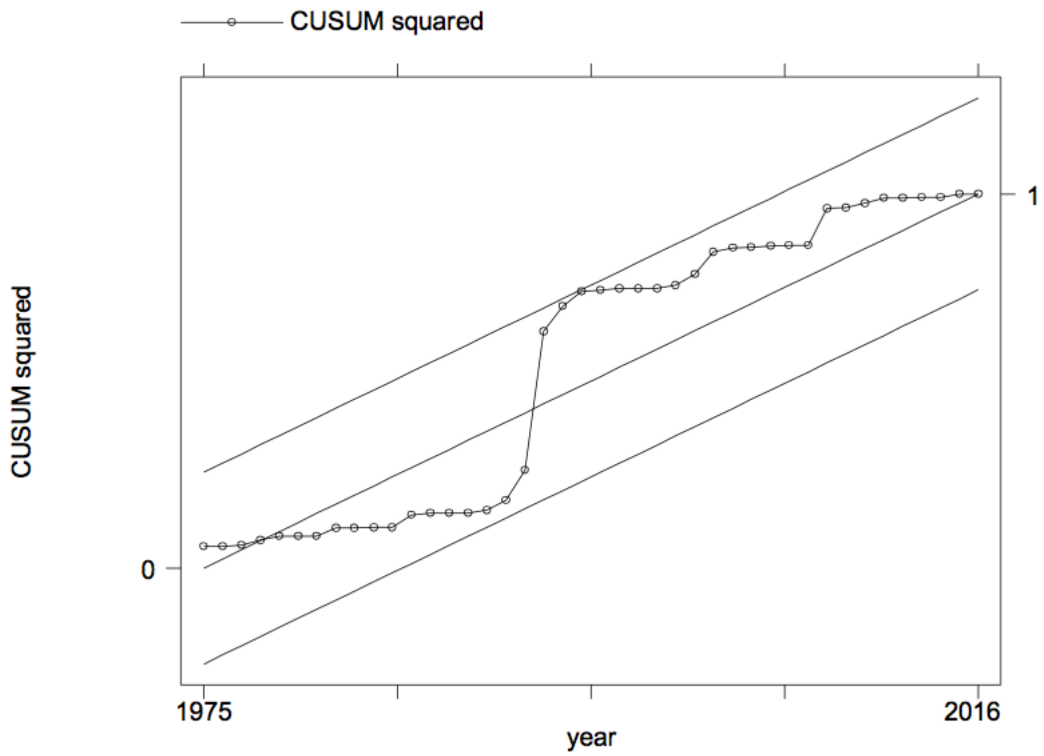
lower
upper
CUSUM
0
0
1975
2016
year


CUSUM squared
CUSUM squared
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