Panel Auto-Regressive Distributed Lag (PARDL) Modeling of Exchange Rate in Oil Driven Economies in Africa

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ABSTRACT

This study on Panel Auto-Regressive Distributed Lag (PARDL) Modeling of Exchange Rate in Oil Driven Economies in Africa, modeled exchange rate, lending interest rate and inflation for six oil producing countries in Africa within 1980 to 2019. These countries are listed as; Algeria, Angola, Egypt, Gabon, Libya and Nigeria. This paper is aimed to build an appropriate Panel Auto-Regressive Distributed Lag (P/ARDL) model for the listed variables for the selected countries, evaluate the pattern of relationship between exchange rate and other economic variables such as lending interest rate and inflation rate in the selected countries. The model is adequate for the study. The exchange rate of the local currencies of the selected countries per USD is the dependent variable, while the explanatory variables are the lending interest rate and inflation. The data used for this research is secondary in nature and the result from the estimation indicates that both lending interest rate and inflation are statistically significant with the same p-value 0.000, meaning that exchange rate is determined by both variables across all the selected six countries that make up the panel. The model obtained will be used to formulate and recommend suitable policy/policies that will improve economic growth in the selected countries. The study therefore recommends that since exchange rate is determined by lending interest rate and inflation, monetary authorities in the region should pursue stabilizing lending interest rate and inflation as swings in these determinants will cause threat in stabilizing exchange rate hence affect economic growth.

KEYWORDS: *Panel Auto-Regressive Distributed Lag, Exchange Rate, Lending Interest Rate, Inflation, Oil Driven Economies.*

1.1 Introduction

Exchange rate is one of the key factors of a country's economic growth. It could also be described as part of a country's monetary policy, where its currency is determined in comparison to other currencies. According to Corporate Finance Institute (CFI) Team (2022) exchange rate is the rate at which one currency can be exchanged for another between nations or economic zones. It is used to determine the value of various currencies in relation to each other and is important in determining trade and capital flow dynamics. For instance, the quotation of exchange rates between two currencies can be understood by knowing how much local currency can be given out in return of one United States' Dollar (USD). Oil driven economies in Africa are referred to

as oil producing countries in Africa. The main oil driven economies in Africa include; Nigeria, Angola, Libya, Gabon, Algeria and Egypt. As at 2019, the leading oil producer in Africa is Nigeria, with 101.4 million metric tons in the country, second and third position are Angola and Algeria which amounted 69.1million and 64.3million metric tons respectively. Exchange rate is the relative worth of the currency of a particular country when exchanged for another country's currency, Dornbusch *et al.* (2004). These exchange rates are fixed in the foreign exchange market, where it is accessed by a web of networks of traders and purchasers of foreign currency. Foreign exchange market provides the mechanism and importance towards foreign currency to bargain for import from overseas.

Inflation is termed to be the general increase in the prices of goods and services in a country. It therefore implies that if the increase in prices persists, the value of the nation's currency will drop. If the country's interest rate is high it causes appreciation in its currency due to the fact that higher interest rate offers higher returns relative to other nations. The high interest rate attracts more foreign capital, thus cause a rise in exchange rate.

The paper focuses on six Africa countries with oil driven economies. Previous studies carried out concerning modeling of exchange rate and other macroeconomic variables like exports, foreign direct investment, interest rate and inflation etc. did not consider oil producing countries in Africa.

A Panel Autoregressive Distributed Lag (P-ARDL) model is used for the study and basically the ARDL model in a panel setting with individual effects unlike a single equation time series set up. Usually standard regression of estimation of ARDL models is difficult because of bias arising from correlation between the mean-differenced regressors and the error term. There are actually many approaches to modeling panel data and the wrong approach or technique will result to misleading conclusion. In particular, Wa-Ntita (2015) explained that panel data modeling takes into cognizance the size of the panel data because it the size that determines the appropriate approach to apply .

The concepts of the Panel Autoregressive Distributed Lag (P-ARDL) model reviewed in this paper focuses on modeling exchange rate on inflation and lending interest rate for six African countries namely Nigeria Angola Libya, Gabon Algeria and Egypt. The dependent variable is the exchange rate while the independent variables are lending interest rate and inflation rate. The possible relationship among these variables is represented in fig 1.1.

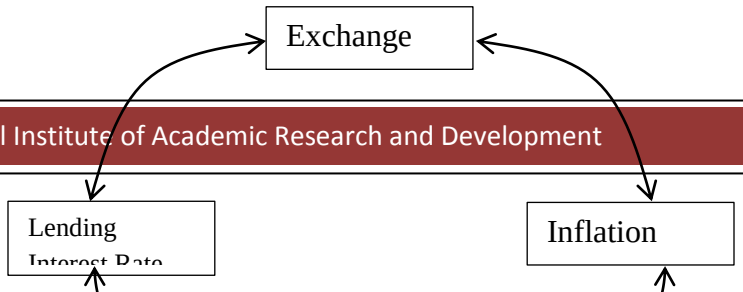

Figure 1.1: Link between Exchange Rate and the selected Macroeconomic Variables

2.1 Literature Review

Several studies have been carried out by different scholars on the relationship between exchange rate and economic growth of different countries.

The Auto-Regressive Distributed Lag (ARDL) Model is a model that tests the presence of long-run relationship between time series or economic variables in a single equation and includes the lags of both the dependent variable and independent variable as regressors. It represents an infinite lag model that is both flexible and parsimonious; in this model the dependent variable is assumed to be a function of the past values of itself and the current and past values of the explanatory variables. Engle and Granger (1987); Hassler and Wolter (2006) revealed that the model became popular after it provided evidence that the equivalence of co-integrated non-stationary variables is an error correction (EC) process, and that the model has its re-parameterization in EC form. The EC representation is the basis upon which the existence of co-integration/long-run relationship can be tested. Pesaran, Shin and Smith (2001) explained that a Bounds Testing procedure is embedded in the model to make conclusive inference without knowing whether the variables involved are integrated of order zero (0) or order one (1).

Shrestha and Bhatta (2018) indicated that what makes this model powerful is that it can be applied on time series data that are non-stationary as well as time series data that have combined order of integration. They concluded that a rise in oil prices and exchange rate appreciation increase stock market prices. Nwafor *et. al.* (2018) state the approach using the transfer function to model these indicators depends on the inter-relationship that exists in the implementation of economic policy specially exchange rate.

Fowowe (2014) modeled the Oil Price-Exchange Rate Nexus for South, the research centered on an empirical analysis of the relationship between exchange rate and oil price in South Africa. The jumps and volatility in exchange rate were estimated using GARCH. According to the result, increase in oil price led to a depreciation of South African rand relative to the US dollar, which implies that wealth from South Africa is being transferred to the OPEC countries as a result of increase in oil price.

Adelakun & Ngalawa (2020), assed the role of oil prices in the degree and direction of pass-through of exchange rate in oil importing and exporting countries. They used a panel data set to explore non-linear panel autoregressive distributed lag (NPARDL) models to account for asymmetries. Their findings show that the declining pass-through of the exchange rate is mainly caused by the phenomenon of developed markets.

Onwukwe and Nwafor (2014) state that one of the key objectives of every good economy, whether or not developing or developed is to achieve a high and sustainable economic growth rate coupled with the economic indicators. The research on the Multivariate Time Series Modeling of Major Economic Indicators in Nigeria, aims at providing quantitative analysis of the dynamics on currency in circulation, exchange rate, external reserve, gross domestic product, money supply and price deflator. This study utilizes secondary data obtained from the Central Bank of Nigeria, Statistical Bulletin (vol. 21: 2010), of all variables investigated in the model. The sample covers quarterly data from 1981 to 2010. The study employed the newly developed multivariate time series estimation technique via Vector Autoregressive modeling to model the economic indicators in Nigeria. The empirical result yields a stable and sustainable economic model for the six economic variables in the study.

Aftab *et.al*, (2017) employed Generalized Autoregressive Conditional Heteroskedasticity (GARCH (1, 1)) to measure exchange rate volatility and autoregressive distributed lag (ARDL) model to study the relationship between exchange rate volatility and trade flows in 62 Malaysian exporting and 60 Malaysian importing industries with Thailand over the monthly period 2000-2013. Findings suggest the influence of exchange-rate volatility on the trade flows in a limited number of industries.

In another study, Bingilar, *et al.* (2020) analyzed the accounting implication of oil price, exchange rate and unemployment on economic growth in Nigeria within 1981 to 2019, with ARDL and VEC model. Results show that all the variables are statistically significant and have both short and long term association, thus imply that the nation's economy relies mainly on oil.

Insah and Chiaraah (2013) examined the variables responsible for real exchange rate volatility in Ghana within the period 1080 – 2012. The economic indicators considered in the work include: external debt, government expenditure, money supply and domestic debt, using the ARDL model. Finding from the study states that there exist positive relationships between exchange rate volatility and government expenditure, while external debts domestic debt and money were negatively connected to exchange rate volatility.

Wa-Ntita (2015) examined the key determinants of access to health care in Africa. ARDL model was applied to a panel data that ranged from 1995 to 2012 in 37 countries. The pooled mean group (PMG) was used to estimate the model. The findings established that a short run and long run relationship exist between exchange rate and the variables in the model.

3.1 Data and Methodology of the Study

This study employed panel data comprising of six oil producing countries in Africa from 1980 to 2019. All the series were sourced from the World Bank National data account. The variables of interest are the exchange rate between the local currencies of the six countries per USD as the dependent variable, while lending interest rate and inflation are the explanatory variables. The Panel Auto-Regressive Distributed Lag (PARDL) Model developed by Pesaran Shin and Smith (2001) is adopted in the study, the model is simply an ARDL model in a panel setting. It is therefore a combination of the ARDL and Panel model.

The general linear Panel ARDL (p,q,q,...q) Dynamic Model is specified as;

$$y_{it} = \sum_{j=1}^{P} \lambda_{ij} yi_{t-j} + \sum_{j=o}^{q} \delta_{ij} X_{i,t-j} + \varphi_i + \varepsilon_{ij} \quad (3.1)$$

$i = 1, 2,\ldots, N$ and $t = 1, 2,\ldots, T$

Where;
y_{it} is a scalar dependent variable,
X_{it} (k x 1) vector of independent variables (regressors),
the X_{it} vary over groups and time period,
λ_{it} is the coefficient of the lagged dependent variable,
δ_{ij} is the coefficient of the lagged independent variable,
φ_i is the unit specific fixed effect,
p and q are the optimal lags of the dependent and independent lags respectively
ε_{it} is the error term.

The ECM version of the Panel ARDL (p, q, q…q) Model is specified as;

$$\Delta y_t = \phi(y_{it-1} - \beta_{1t} X) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{it-1} + \sum_{j=0}^{q-1} \beta_{ij} \Delta X_{it-1} + u_i + \varepsilon_{ij} \quad (3.2)$$

Considering the variables used in this study, the PARDL model in Equation (3.2) is then re-parameterized into an ECM form and expressed as follows:

$$\Delta excr_{it} = \phi i \ (y_{i,t-1} - \theta_1 \text{lir}_{i,t-1} - \theta_2 \text{infl}_{i,t-1})$$

$$+ \sum_{j=1}^{p-1} \lambda_{ij} \Delta excr_{it-j} + \sum_{j=o}^{q-1} \delta_{1ij} \Delta lir_{i,t-1} + \sum_{j=o}^{q-1} \delta_{2ij} \ \Delta infl_{i,t-1} + \omega_j + U_{it} \quad (3.3)$$

i=1,2,…,6 (countries) t =1,2,…,39 (years)

Where for any i at time t:
$excr_{it}$ is the logarithm of exchange rate
lir_{it} is the logarithm of lending interest rate
$infl_{it}$ is the logarithm of inflation

All the variables in Equation 3.3 are differenced. The θ_{ki} and $\delta_{k,I,t}$ are the long-run and the short-run independent variables coefficients (k =1,… δ). The λ_{ij} are the coefficients on lagged exchange rates. ω_i represents the fixed effects while the U_{it} represents the idiosyncratic error terms.

However, worthy of note is the fact that when panels of data are involved in a study, the panel co-integration usually has three competing estimators Wa-Ntita (2015), these estimators are; the mean group (MG) estimator Pesaran & Smith, (1995), the pooled mean group (PMG) estimator

Pesaran *et al*., (2001), and the dynamic fixed effect (DFE) estimator. At the end of the analysis, one estimator is chosen depending on how well it fits the data.

4.1 Result

Preliminary statistical analysis such as the time series plot was carried out to determine the stationarity of the series and the trend of the data. The study yields the model from section 3.3 and estimated in table 4.1 which by empirical analysis obtained as:

$$\begin{pmatrix} Excr_{Algeria} \\ Excr_{Angola} \\ Excr_{Egypt} \\ Excr_{Gabon} \\ Excr_{Libya} \\ Excr_{Nigeria} \end{pmatrix} = \begin{pmatrix} -0.8160_{excr-1} \\ 0.8020_{excr-1} \\ -0.4847_{excr-1} \\ -0.3886_{excr-1} \\ -0.7837_{excr-1} \\ -0.9903_{excr-1} \end{pmatrix} + \begin{pmatrix} 0.0239_{lir-1} \\ 0.0193_{lir-1} \\ 0.0692_{lir-1} \\ -0.0005_{lir-1} \\ 0.0589_{lir-1} \\ 0.0406_{lir-1} \end{pmatrix}$$
$$+ \begin{pmatrix} 0.0103_{inf-1} \\ 0.0017_{inf-1} \\ -0.0434_{inf-1} \\ 0.0088_{inf-1} \\ 0.0026_{inf-1} \\ 0.0022_{inf-1} \end{pmatrix} + \begin{pmatrix} -0.1465 \\ 0.0146 \\ -0.0336 \\ -0.0348 \\ -0.0132 \\ 0.0150 \end{pmatrix} \quad (4.1)$$

The study further evaluated Equation (4.1) which generated the model for each study country as could be seen below:

$$Excr_{Algeria} = -0.8160_{excr-1} + 0.0239_{lir-1} + 0.0103_{inf-1} - 0.1465 \quad (4.2)$$
$$Excr_{Angola} = 0.8020_{excr-1} + 0.0193_{lir-1} + 0.0017_{inf-1} + 0.0146 \quad (4.3)$$
$$Excr_{Egypt} = -0.4847_{excr-1} + 0.0692_{lir-1} - 0.0434_{inf-1} - 0.0336 \quad (4.4)$$
$$Excr_{Gabon} = -0.3886_{excr-1} - 0.0005_{lir-1} + 0.0088_{inf-1} - 0.0348 \quad (4.5)$$
$$Excr_{Libya} = -0.7837_{excr-1} + 0.0589_{lir-1} + 0.0026_{inf-1} - 0.0132 \quad (4.6)$$
$$Excr_{Algeria} = -0.9903_{excr-1} + 0.0406_{lir-1} + 0.0022_{inf-1} + 0.0150 \quad (4.7)$$

The study shows that there exist a very strong correlation between the variables of interest, exchange rate with lending interest rate, exchange with inflation and lending interest rate with inflation having the following values: 0.82, 0.83 and 0.76 respectively see table 4.2. The graph of the variables under study was plotted with their respective years of occurrence, see figure 4.1, 4.2 and 4.3. From the analysis equation 4.1 to 4.7 represents the individual equation for the respective study countries. The model so estimated in equation 4.1 is adequate for economic policy.

5.1 Conclusion

Panel Auto-Regressive Distributed Lag Modeling of exchange rate in oil driven economies over the period 1980 to 2019 was painstakingly achieved through the objective of building an

appropriate Panel Auto-Regressive Distributed Lag (Panel ARDL) Model for Exchange rate in selected countries, evaluating the relationship between exchange rate and other economic variables such as lending interest rate and inflation rate in the selected countries. Following the review of literature, the study discovered the possible factors that influence exchange rate as lending interest rate and inflation. In analyzing the data, both descriptive and inferential statistics were involved. Under the descriptive, time plots and summary statistics were considered. The model obtained will be used to formulate and recommend suitable policy/policies that will improve economic growth in the selected countries. The study therefore recommend since exchange rate is determined by lending interest rate and inflation, monetary authorities in the region should pursue stabilizing lending interest rate and inflation as swings in these determinants will cause threat in stabilizing exchange rate hence affect economic growth.

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Appendix

Table 4.1: Result of full PMG Regression

D. EXCR	COEF.	STD. ERR.	Z	P > /Z/	(95% CONF.

	INTERVAL)					
LR						
LIR	.008913	.002206	4.04	0.000	-.0045894	.0132376
INFL	-.0007358	.0001849	3.98	0.000	-.0003734	.0010981
SR						
ALGERIA						
EC	-.8160424	.1449878	-5.63	0.000	-1.100213	-.5318715
LIR	.0238854	.0197315	1.21	0.226	-.0147877	.0625584
INFL	.0103420	.0040088	2.58	0.010	.0024857	.0182
CONS	-.0146526	.0284951	-0.51	0.607	-.0705019	.0411967
ANGOLA						
EC	-.802004	.2572263	-3.12	0.002	-1.306158	-.2978497
LIR	.019306	.0057433	3.36	0.001	.0080494	.0305627
INFL	.0001748	.0001868	0.94	0.349	-.0001913	.000541
CONS	.0145574	.109244	0.13	0.894	-.199557	.2286718
EGYPT						
EC	-.4848731	.135455	-3.58	0.000	-.7503217	-.2194244
LIR	.0691843	.0191181	3.62	0.000	.0317135	.1066551
INFL	-.0043409	.0037771	-1.15	0.250	-.0117439	.0030621
CONS	-.0335542	.0267425	-1.25	0.210	-.0859685	.0188602
GABON						
EC	-.3885599	.1220196	-3.18	0.001	-.6277139	-.149406
	-.0005084	.0018061	-0.28	0.778	-.0040482	.0030314

LIR						
INFL	.0087523	.0027093	3.23	0.001	.0034421	.0140626
CONS	-.034791	,0258952	-1.34	0.179	-.0855445	.0159626
LIBYA						
EC	-.7836776	.1694214	-4.63	0.000	-1.115737	-.4516178
LIR	.0588747	.1385605	0.42	0.671	-.2126988	.3304483
INFL	.0026322	.0050879	0.52	0.605	-.00734	.0126043
CONS	-.013204	.0262189	-0.50	0.615	-.064592	.0381841
NIGERIA						
EC	-.9902718	.1634728	-6.06	0.000	-1.310678	-.6698708
LIR	.0406112	.0153193	2.65	0.008	.0105858	.0706365
INFL	.0021795	.0029937	0.73	0.467	-.0036881	.008047
CONS	.0149677	.0562185	-0.27	0.790	-.1251539	.0952184

Table 4.2: Result of Correlation Analysis

Variables	**Excr**	**Lir**	**Infl**

Excr	1.000000		
p-value	.000		
Total observation	223		
Lir	0.816153	1.000000	
p-value	0.000	0.000	
Total observation	223	223	
Infl	0.825965	0.760967	1.000000
p-value	0.000	0.000	0.000
Total observation	223	233	223

Source: Researcher's compilation using e-views software

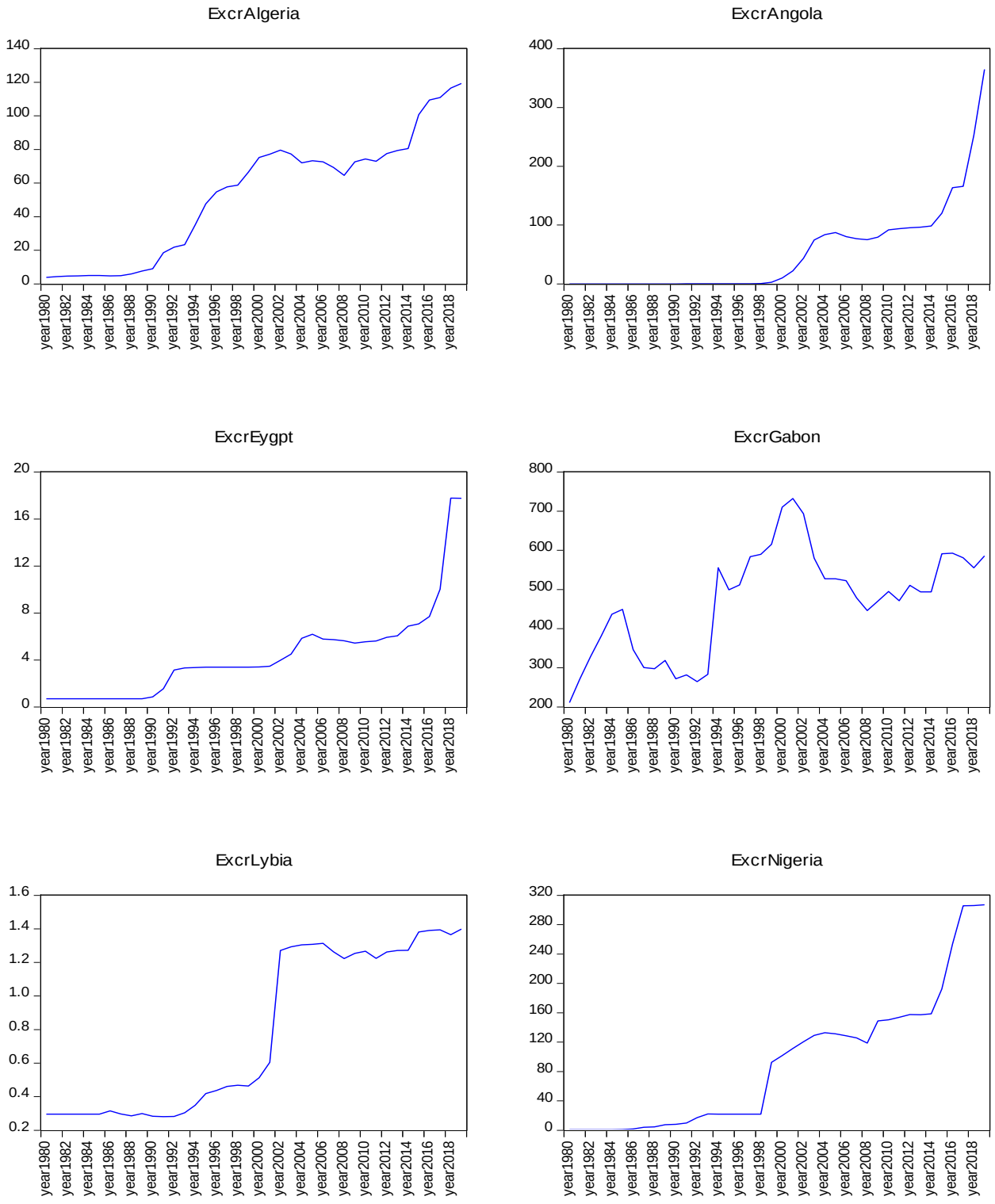


Figure 4.1: Annual Raw Exchange Rate (Local Currencies/US Dollar) from 1980 – 2019 for the Selected Six Oil Producing Countries in Africa.

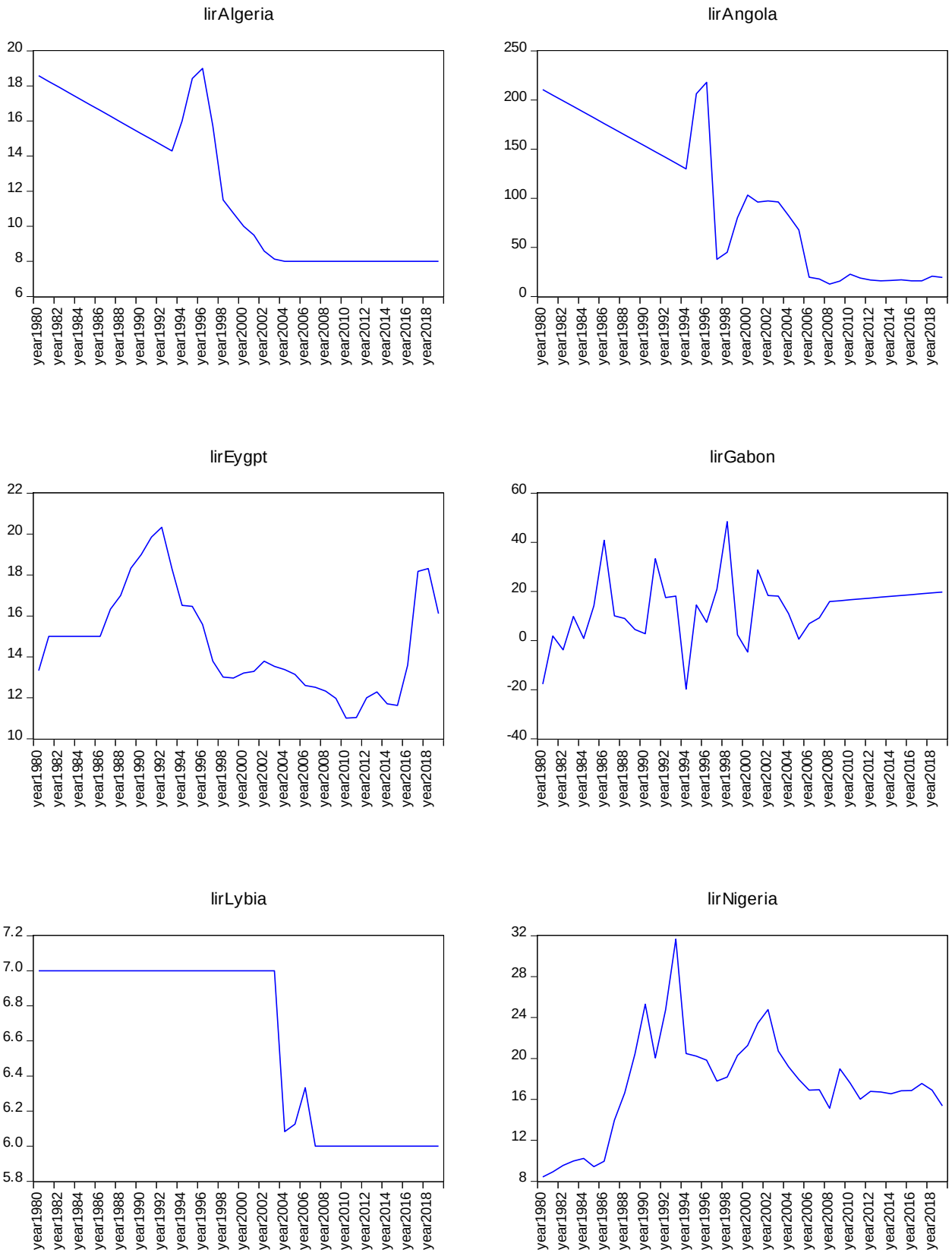
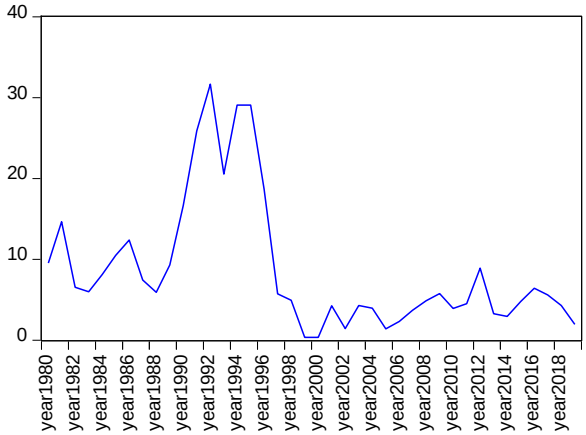


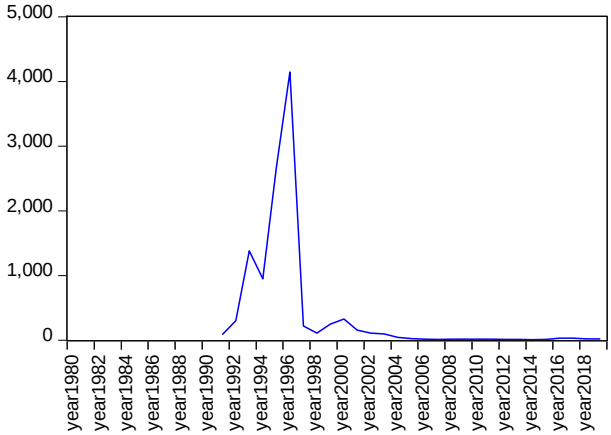
Figure 4.2: Annual Raw Lending Interest Rate from 1980 – 2019 for the Selected Six Oil

Producing Countries in Africa

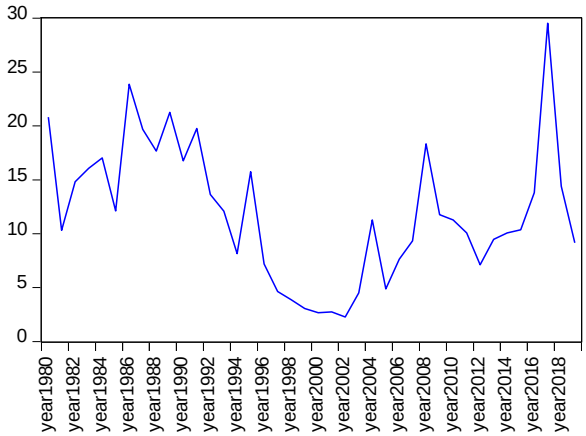
infAlgeria



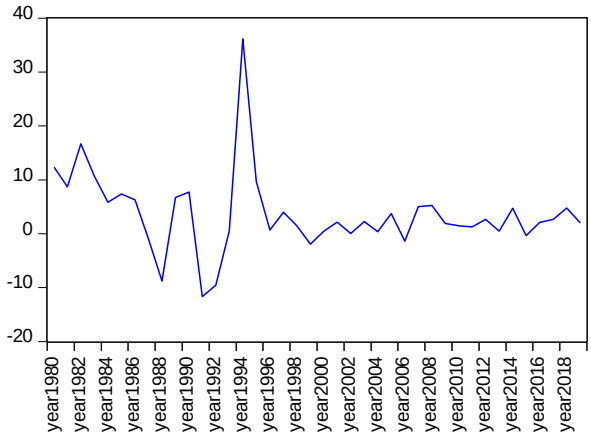
infAngola



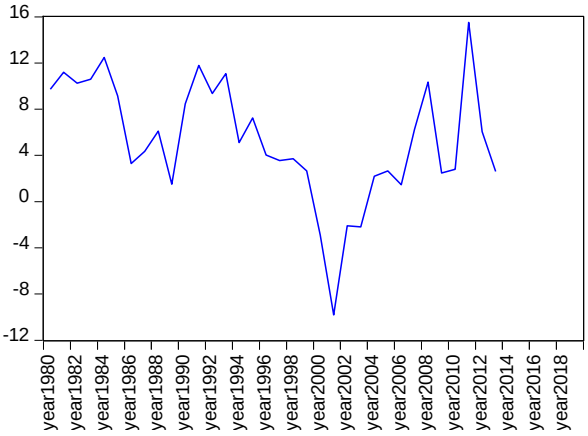
infEygpt



infGabon



infLybia



infNigeria

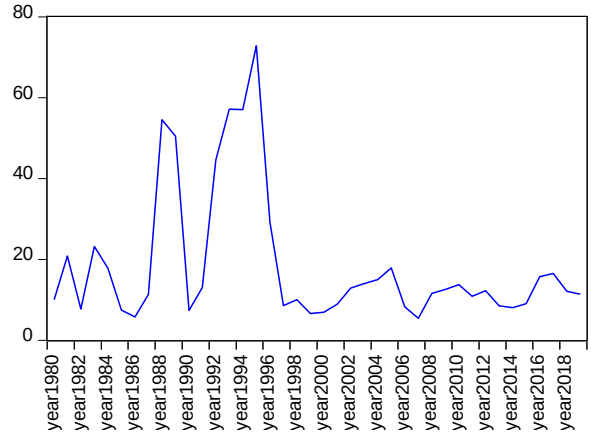


Figure 4.3: Annual Raw Inflation from 1980 – 2019 for the Selected Six Oil Producing Countries in Africa