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TAYLOR RULE AND MONETARY POLICYMAKING IN SUB-SAHARAN AFRICA

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ABSTRACT

This study examined the Taylor rule for the SSA. Most importantly, it examines the interrelationship between interest rate and inflation rate in Nigeria, Ghana and Kenya. The effects of some other variables on inflation rate is also examined. Interest rate can be adjusted to address inflation rate. The main objective is to check whether inflation rate can be amenable to interest rate adjustment. If so, interest rate can be used as a simple policy instrument followed the Taylor rule. The rule has been tested for the United States and many other economies of the world. The method used is OLS and estimation techniques is based on VECM. Impulse response is also obtained to check responses of inflation to shocks from exogenous variables. The results reveal that Ghana can adopt the Taylor rule, which means that Ghana can embark on inflation targeting using interest rate or monetary policy rate as nominal anchor. Nigeria can also adopt the proposition but need a considerable maintenance of a stable macro economy. Even though Kenyan economy appears to be statistically more vibrant, the results does not approve the country for Taylor rule. It is suggested that the SSA requires a stable macro economy for monetary policymaking in the 21st century. A successful monetary policy stance rest on a stable, reliable and relatively predictable framework that can create desirable growth.

Keywords: Inflation targeting, Interest Rates, Sub-Saharan Africa, Shocks, Impulse Responses, VECM

INTRODUCTION

The Taylor Rule is a set of monetary policy rules applicable in a policymaking environment. The rules refer to changes in the monetary policy or the central bank rate in response to changes in the price level or changes in real income (Taylor, 1993). The need to adjust central bank fund rate is induced by targets set for output and price. Taylor (1993) explains “monetary policy rules in which the short-term interest rate instrument is raised by the monetary authorities if the price level and real income are above a target and is lowered if the price level and real income are below target, seem to work well”. Apart from policy rule, discretionary policy has also been put forward to address monetary policy. For instance, Laidler (1991) argues that discretionary policy is to be relying on in order to maintain price stability. However,

Taylor maintains that policy rules have major advantages over discretion in improving economic performance. He stresses the need to retain the concept of a policy rule even in an environment where it is almost impossible to follow automatically the numerical formulas economists use to define their preferred policy rules. According to the Central Bank of Kenya (CBK), central bank monetary policy rules are made to maintain a low and stable inflation rate over time, which is an indication of price.

The extent of policy rule effectiveness in the sub-Saharan African (SSA) countries might be unknown. Nonetheless, authors such as Adebiyi (2009), Afolabi and Atolagbe, (2019) have found that policy rules might not necessarily have effects on most SSA economies. In fact, Adebiyi (2009) findings suggest Nigeria and Ghana are not ripe for policy rule such as the Taylor rule. Wu and Xia (2014) and Bernanke (2020) advocate policy rule but with some levels of caveat. The objective of this study is to investigate whether selected countries in the SSA are suitable to adopt policy rule or to follow traditional method of discretion or control. In this study, the Taylor rule is followed to explain it might be preferable to have policy rule to avoid complicated arithmetic often written down to describe the preferred policy rules. This topic would be thoroughly examined better than the previous authors, and maintain a significant rule-based suggestion. The three countries to be examined, which include Nigeria, Ghana and Kenya, are selected because they appear to be among the most developing countries in SSA and are in the medium income group as classified by the World Bank.

LITERATURE REVIEW

Theoretically, the central bank is always on empirical research to secure optimal policy option that would stabilize price and increase economic growth. In fact, the primary duty of the central bank is to ensure the economic grows and it is stable. Options available are policy instruments re-address based on current level of changes in price and output. In a typical monetary policy committee meeting, the committee members examine changes in developed countries, emerging economies and domestic economy on the basis of which short run policy decision is arrived at. Interest rate (for instance, monetary policy rate) is usually the primary instrument to adjust to address inflation and output changes before any other such as exchange rate and money supply. It appears that interest rate is a key policy instrument that can be used as a transmission channel to achieve inflation or output targeting.

Inflation is the persistent rise in general price level when output growth is stagnant or not increasing at the same pace. Inflation rate is change in the price level and it is an indicator of economic performances. On the other hand, interest rate is a transmission channel to achieve an objective or a target. The effort to curb inflation is a serious work for the monetary authority. This is vital because persistent rise in

inflation rate may climax into hyper-inflation and may become too difficult to suppress. Keynes (1936) argued that inflation occurring when economic production and aggregate demand exceeds society's endowed resources capacity. Friedman (1970) established inflation is purely fiscal policy driven, but not monetary policy. Once money growth is not beyond output growth, there cannot be inflation, adding that inflation is driven primarily by fiscal expenditure financed by printing of currency. Nevertheless, interest rate adjustment can be used to check inflation and make necessary adjustment. Studies which submit that interest rates are key to attaining stable macro economy and to keep inflation within manageable level include Black (1995), Kiley and Roberts (2017), Kiley (2019). They note that interest rates specification could help regulate inflationary temperature when the monetary authority is at cross road. Kiley (2019) unequivocally further stressed it might be futile modelling interest rate without considering nominal and real interest rates effects on demand and supply of capital, but not clear on whether this also has effect on inflation targeting

Empirically, following the Federal Reserve's monetary management in recent years, one notices a pattern of monetary policy management which allows interest rate to rise when inflation rate rises and interest rate fall when inflation rate falls. Taylor (1993) observes that monetary policymaking tends to adjust interest rate, set target for inflation and output. When inflation rate increases above target, then interest rate is raised. However, when it appears inflation rate is approaching zero or below target, then interest rate is lowered. This is done apparently to induce money or investment demand and consequently increases money supply. Several authors such as Wu and Xia (2014) and Bernanke (2020) have confirmed this policy pattern proved well suited for the advanced countries, especially, the United States and some European countries, only few known work have attempted examining whether such pattern of policymaking would be appropriate in the SSA. Some of these include Buffie (2003), Adebiyi (2009), Bello and Saulawa (2013), Khumalo, Mutambara and Assensoh-Kodua (2017), Sakyi, Mensah and Obeng (2017) and Ochieng, Mukras and Momanyi (2016). In the findings of these studies, there are mix reactions. While some authors proved interest rate and inflation targeting might be practicable, others decline.

Buffie (2003) work is based on effect of restrictive monetary policy on inflation and interest rate. He devises various models which he is able to prove that tight money sparks increase in both inflation and interest rates in Nigeria and Kenya. Although, his work is basically not on setting targets but impact of contractionary monetary policy, but setting targets amidst policy instrument negative outcome might be pessimistic. Adebiyi (2009) study on Ghana and Nigeria shows that the two countries are not

ready for inflation targeting. However, it appears few years later, Sakyi et al (2017) findings for the Ghanaian economy reveal the interest rate pass-through is effective in the short run, but ineffective in the long run. In other words, inflation target should be short run policy and not suitable for Ghana in the long run. In Kenya, Ochieng et al (2016) found that interest rate and money supply growth have no relationship with inflation rate. They suggest that interest rate might be incongruous to curb inflation but other macroeconomic variables such as changes in oil prices and real gross domestic product (GDP) growth would have solutions to inflation threat in Kenya. Ochieng, Mukras and Momanyi (2016) also confirm the weak relationship between interest rate and inflation rate. In Swaziland, Khumalo et al (2017) findings reveal a positive relationship between inflation and interest rate. However, they do not suggest whether interest rate is instrumental to inflation rate targeting. It appears these series of literature indirectly suggesting interest rate might be ineffective to use as transmission mechanism to attain inflation targeting in SSA.

METHODS

Attempt to find the short and long run relationship among monetary policy variables through impulse responses and variance decomposition. These are preceded by descriptive analysis expected to give a brief analysis of historical and current nature of the economies via the variables employed. The description will include finding the mean, standard deviation and other relevant statistics. The data to be employ are time series often with the issue of unit root. Therefore, we would perform stationarity test. What follows will be the co-integration test to ascertain the long run viability of the relationships. Estimation would be based on the traditional ordinary least square (OLS) and the model set is vector error correction (VEC). The VEC model is necessary having tested the variables are co-integrated. In the literature, Engle and Granger (1987), Johansen (1988), Johansen and Juselius (1990), Pesaran et al (2001) are some of the methods used to establish co-integration or to ascertain the existence of long run relationship between two or more variables. Otherwise, vector auto-regression (VAR) model is appropriated. VAR originates from Sims (1986). He proposes that VAR permits impulse responses and variance decomposition and it makes possible the measurement of shocks or innovations to one variable on another. In VAR, every variable determines every other variable stated in the model. In other words, it allows simultaneous estimation of variables (Sims, 1986). Adrangi and Allender (1998) state that VAR models are the best method for investigating shocks transmission among variables because they provide information on impulse responses. With the VEC model, impulse response and variance decomposition can be obtained just as in unrestricted VAR. With reference to Adebiyi, (2009), Ochieng et al (2016) and Sakyi et al (2017) model specifications, the model for this study is

made.

The Model:

IF = f (MP, GG, EX) (1)

In equation (1) the expression states that there is a relationship between inflation rate (IF) monetary policy rate (MP), GDP growth rate (GG), Exchange rate (EX). This study attempts examining whether the three independent variables would be relevant in setting target for inflation rate. For about two decades each economy of the selected sub-Saharan Africa, that is, Nigeria, Ghana and Kenya, monetary authority has been adjusting interest rate to check inflation rate and to prevent inflation from spiraling out of control. However, from the literature review, it is ascertained that other variables like exchange rate and economic growth might play significant role in checking inflation rate. As a result, this study includes the two variables in the model. Following the Taylor rule, it is expected that inflation and interest rate have direct relationship. On the other hand, economic growth and exchange rate are expected to have indirect relationship with inflation rate.

Equation (1) is expressed as VEC model in equation (2):

$$\Delta Y_{it}=\alpha_1+\alpha_2 ect_{t-1} + \alpha_3 \Delta y_{it-1} + \alpha_4 \Delta x_{it-1} + \varepsilon_{it1} \quad (2)$$

Where:

Y_{it} = Endogenous variables.

x_{it-1} = Lag value of each exogenous variable.

α_{i4} = Coefficients of exogenous variables

α_1 = the intercept

ect = Error correction term (ect)

α_2 = Coefficient of ect

Δ = Symbol of difference operator

ε_{it1} = Error term for each model

The ect as stated above measures the speed of adjustment of a variable (dependent variable) to its equilibrium level. In order to establish the join effect of variables, under VECM all those variables are taken as endogenous and exogenous in order to establish the long and short run association between them. The study applies a VEC model with at least one co-integrating equations. With e-views application,

estimation is performed with OLS, a system of four equations, ordered by each variable. Short run effects are captured through individual coefficients of the differentiated terms. The coefficient of the ect measures the inclination of each variable to revert to equilibrium. If the coefficient is negative and significant, it implies that previous equilibrium errors play a role in determining the current outcomes captured in the long-run effect.

The VAR model is expressed as:

$$x_t = A_0 + A\,[L]\, x_{t-1} + \mu_t \qquad (3)$$

Where x_t is an exogenous variable, A [L] is a matrix polynomial in the lag operator of variables. x_{t-1} is the lag value of exogenous variables. μ is the vector of estimated shocks for each of the macroeconomic variables and it is assumed serially uncorrelated. Equation (1) can also be expressed in VAR (matrix notation) of a multivariate auto-regressive model, AR (1). This is done to derive the impulse response and variance decomposition. However, the impulse for this study's model would be derived from VECM.

The short run VECM is stated in (4) below:

$$dINF_t = \alpha_0 + \alpha_1 d\sum INF_{t-l} + \alpha_2 d\sum MP_{t-l} + \alpha_3 d\sum GG_{t-l} + \alpha_4 d\sum EX_{t-l} + \varepsilon_{ti} \qquad (4)$$

Where d represents difference value and ε_ti is the error term of variables in the model

While the long run VECM is stated in (5) below:

$$INF_t = \alpha_0 + \alpha_1 \sum INF_{t-i} + \alpha 2 \sum MP_{t-i} + \alpha 3 \sum GG_{t-i} + \alpha_4 \sum EX_{t-i} + \varepsilon_{ti} \qquad (5)$$

Data for this study are sourced from the statistical bulletin of the Central Banks of Nigeria, Ghana and Kenya. It covers annual data from 2000 to 2019. Unlike Nigeria, reliable monthly or quarterly data are not available in Ghana and Kenya. However, the study would make use of available reliable annual data from the three countries

in order to be on the same pedestal statistically.

PRESENTATION OF RESULTS

Descriptive analysis

The descriptive statistics is displayed in table 1 which is divided into three panels: A, B, and C. Panel A covers the period from year 2000 to 2019, while panel B and C show the decomposition of the 19 years into two periods, 2000-2008 and 2009-2019. Decomposition allows the capturing of behavioural pattern of variables used and also shows the trend of economic statistical indicators in individual country within the specific period under review.

Table 1: Statistical facts about variables used for the regression analysis, 2000 to 2019

Panel A: Analysis of Descriptive Statistics, Year 2000-2019

Descriptive Statistic

Nigeria	Statistics	IF	MP	GG	EX
	Mean	11.17349	12.79000	6.280285	169.5525
	Median	11.34229	12.90000	5.102740	149.5888
	Maximum	17.24680	19.30000	33.73578	306.9210
	Minimum	5.107335	6.100000	0.010000	101.6973
	Std. Dev.	3.026436	3.358712	6.961118	67.32788
	Skewness	0.057028	-0.109629	3.219229	1.266926
	Kurtosis	2.680711	2.688982	13.49364	3.118778
	Jarque-Bera	0.095795	0.120672	126.3086	5.362091
Ghana					
	Mean	14.55600	18.92700	6.216155	2.023058
	Median	12.49500	17.86500	5.700000	1.417475
	Maximum	32.91000	26.00000	14.05000	5.217367
	Minimum	7.130000	12.75000	3.450000	0.544919
	Std. Dev.	6.981078	4.705078	2.578490	1.504599
	Skewness	1.186686	0.330241	1.453784	0.925999
	Kurtosis	3.740491	1.610662	5.205983	2.346642
	Jarque-Bera	5.151015	1.972080	11.10026	3.213975
Kenya					
	Mean	7.738759	8.660000	4.706634	84.15515
	Median	6.477074	8.000000	5.361437	79.20360
	Maximum	20.78569	17.50000	8.405699	103.4104
	Minimum	0.621087	2.500000	0.232283	67.31667

	Std. Dev.	4.314290	3.668558	2.204961	11.55015
	Skewness	1.206607	0.938953	-0.808068	0.473776
	Kurtosis	5.450626	4.170812	2.894992	1.949307
	Jarque-Bera	9.857645	4.081112	2.185768	1.668175

Source: Author's computation, CBN Statistical Bulletin and WDI, 2019

Table 1, Panel A comprises statistics from 2000-2019. Observation from the statistics shows that the series relatively have large differences between the minimum and maximum values. This represents instability in the macroeconomic framework in the three countries, Nigeria, Ghana and Kenya. However, looking more conscientiously, Kenya has a more relatively stable macroeconomic framework between 2000 and 2019. This is noticeable from her mean inflation rate which is 7.7% as against Nigeria and Ghana which are 11.17% and 14.55% respectively. By the international standard, economic growth rate for the three countries is acceptable but average exchange rate (EX) for Nigeria (169.55) appears to be too high and economically unsustainable. Unfortunately, in year 2019 and 2020, the exchange rate has gone wild, approaching 600 naira to 1 US dollar. This projects negative implications on manufacturers who would import at high prices which also further heightens inflation rate. Except MP for the Nigerian economy and GG for the Kenyan economy, the rest of the variables are positively skewed. Nonetheless, some of the data are highly skewed, for instance, GG and EX for Nigeria; IF and GG for Ghana and IF for Kenya. This is because the skewness values are greater than (+1). It means these data are far from being normally distributed. That is they might be asymmetrically distributed.

A kurtosis value is either greater than or less than 3.0. Two variables in each country are greater than 3.0, in other words, these variables are leptokurtic distributed. That is the data has kurtosis larger (or flatter) in the tails than that of a normal distribution. For instance, we have GG and EX for Nigeria; IF and GG for Ghana and IF and MP for Kenya. On the other hand, the remaining variable are platykurtic, that is, the data set has lighter tails than a normal distribution. However, a test of stationarity before model estimation would give a clearer result.

Table 2 Panel B: Analysis of Descriptive Statistics, Year 2000-2008

Nigeria	**Statistics**	**IF**	**MP**	**GG**	**EX**
	Mean	12.01455	14.46667	9.150896	122.2131
	Median	12.30515	15.00000	6.270264	125.8081
	Maximum	17.24680	19.30000	33.73578	132.8880
	Minimum	5.107335	9.100000	3.444667	101.6973

	Std. Dev.	3.928190	3.447100	9.479938	10.35034
	Skewness	-0.407922	-0.276210	2.228635	-0.884116
	Kurtosis	2.202750	1.984882	6.408018	2.645541
	Jarque-Bera	0.487953	0.500862	11.80569	1.219608
Ghana					
	Mean	18.38889	19.83444	5.411111	0.847235
	Median	15.12000	18.86000	5.200000	0.899495
	Maximum	32.91000	25.82000	9.150000	1.052275
	Minimum	10.73000	12.75000	3.700000	0.544919
	Std. Dev.	7.908325	5.371608	1.660719	0.146609
	Skewness	0.750470	-0.012890	1.259737	-0.847293
	Kurtosis	2.130316	1.286069	3.898969	3.201050
	Jarque-Bera	1.128438	1.101834	2.683460	1.092016
Kenya					
	Mean	9.399024	7.055556	3.602823	74.74942
	Median	8.938332	7.500000	3.779906	75.93557
	Maximum	20.78569	10.00000	6.850730	79.17388
	Minimum	1.923581	2.500000	0.232283	67.31667
	Std. Dev.	5.282743	2.777639	2.658594	4.294363
	Skewness	0.898187	-0.624322	-0.146079	-0.654905
	Kurtosis	3.682119	2.058788	1.436041	2.035856
	Jarque-Bera	1.384593	0.916872	0.949247	0.991940

Source: Author's computation, CBN Statistical Bulletin and WDI, 2019

Table 3: Panel C: Analysis of Descriptive Statistics, Year 2009-2019

Nigeria	**Statistics**	**IF**	**MP**	**GG**	**EX**
	Mean	10.48535	11.41818	3.931604	208.2847
	Median	10.88695	12.20000	4.279277	158.5526
	Maximum	13.56723	14.00000	7.839739	306.9210
	Minimum	7.456578	6.100000	0.010000	148.8800
	Std. Dev.	1.975001	2.706961	2.586301	69.71343
	Skewness	-0.230754	-0.963388	-0.010922	0.606203
	Kurtosis	1.942345	2.489966	1.748751	1.550009
	Jarque-Bera	0.610327	1.820774	0.717797	1.637351
Ghana					
	Mean	11.42000	18.18455	6.874828	2.985095
	Median	10.71000	17.33000	6.480000	2.896575
	Maximum	19.25000	26.00000	14.05000	5.217367
	Minimum	7.130000	12.75000	3.450000	1.404967

	Std. Dev.	4.303973	4.198920	3.060302	1.421860
	Skewness	0.656800	0.586743	1.053159	0.201596
	Kurtosis	2.053715	2.188797	3.748912	1.490666
	Jarque-Bera	1.201291	0.932763	2.290496	1.118632
Kenya					
	Mean	6.380360	9.972727	5.609752	91.85076
	Median	6.175889	8.000000	5.718507	88.81167
	Maximum	12.29728	17.50000	8.405699	103.4104
	Minimum	0.621087	6.500000	3.306940	77.35083
	Std. Dev.	2.920339	3.896945	1.260665	9.692901
	Skewness	0.073814	1.188719	0.443307	-0.131474
	Kurtosis	3.648028	2.851751	3.971007	1.501837
	Jarque-Bera	0.202462	2.600669	0.792430	1.060416

Source: Author's computation, *CBN Statistical Bulletin and WDI, 2019*

There only slight differences among the variables trend between year 2000-2008 and 2009-2019. Average inflation rate in Nigeria for 2009-2019 is less than 2000-2008. Monetary policy rate is also lesser in 2000-2019 as against 2000-2008. However, while economic growth is higher in 2000-2008, exchange rate is higher in 2009-2019. The implication for Nigeria is that it appears the economy performs better from year 2000 to 2008 than 2009 to 2019. The performance in Ghana in the two period is not significantly different. In Kenya, GG increases from 3.6% in 2000-2008 to 5.6% in 2009-2019. Monetary policy rate (MP) and inflation rate (IF) in Kenya are double digits in the two episodic period. Overall, Kenyan economy appears sound in macroeconomic policy management than Nigeria and Ghana.

EMPIRICAL RESULTS

Unit Root Test

The unit root test will be carried out to check for stationarity of the variables used for the regression analysis. Unit root test is essential to avoid spurious regression results and the exercise is the first step to the regression analysis.

Table 4: Unit of Root Test Results

Country	Variables	ADF Test at Level	ADF Test at 1st Difference	PP Test at Level	PP Test at 1st Difference	Order of Integration
Nigeria						
	IF	-3.145071	-4.631123	-3.182907	-5.310560	I(1)
	MP	-1.485587	-3.988959	-1.510675	-3.998277	I(1)

	GG	-1.819926	-6.486805	-3.543785	-13.65677	I(1)
	EX	1.888912	-2.059796	0.833438	-2.140870	I(1)
Ghana						
	IF	-2.413478	-7.958241	-2.661947	-7.878781	I(1)
	MP	-0.872674	-2.988406	-1.594197	-6.297261	I(1)
	GG	-0.758894	-5.708617	-2.948556	-5.913754	I(1)
	EX	*5.314158	*4.247489	2.622632	-3.573789	I(1)
Kenya						
	IF	-3.382516	-5.538877	-1.269874	-11.85066	I(1)
	MP	-4.147686	-8.393146	-4.179442	-10.84418	I(1)
	GG	-2.892261	-5.281520	-3.849192	-11.17721	I(1)
	EX	-0.196287	-3.584891	-0.258311	-3.628895	I(1)

Author's computation with E-views 10.0

The Augmented Dickey Fuller and Phillips-Perron (PP) tests are presented in table 4. It is found that the variables are integrated of order one. That is all the variables have unit root but are stationary at first difference. Generally, it is common for times series data to have unit root. A regression exercise without examining the time series properties of the variables could generate spurious results (Engle and Granger, 1987). Nevertheless, except Kenya, exchange rate for each of Nigeria and Ghana tends to be non-stationary at first difference until the test equation excludes intercept and trend. This represents instability in the macro economy sparking poor records of macroeconomic variables.

Lag Length Criteria

Table 5: Lag Length Criteria

Nigeria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-261.5400	NA	16198927	27.95157	28.15040	27.98522
1	-217.6991	64.60758*	909065.2*	25.02096*	26.01510*	25.18921*

Ghana

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-182.7749	NA	4061.857	19.66051	19.85934	19.69416
1	-127.3700	81.64925*	67.48128*	15.51264*	16.50678*	15.68088*

Kenya

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-214.2692	NA	111813.3	22.97570	23.17453	23.00935
1	-186.7438	40.56376*	34951.55*	21.76250*	22.75665*	21.93075*

Source: Author's computation using E-views 10.0 (2020),
* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)

The next step is the selection of an optimal lag length. This is very essential before carrying out a Johansen co-integration test because it is lag sensitive. As seen in table 5, five criteria are assessed and tested at 5% level of significance. Although different lag length are revealed by each criterion, in this study, all the criteria select optimal lag of (1) for each country's variables. All the criteria satisfying lag (1) might be the result of relatively low observation arising from in-availability of reliable monthly or weekly data from Ghana and Kenya to compliment Nigeria.

Co-integration Test

The next regression analysis is the co-integration test. The Johansen co-integration test with respect to the Trace and Eigenvalue statistic tests are presented in Table 4. The Johansen co-integration test is important because it allows testing for the long run direction of the variables.

Table 6: The Johansen Co-integration Test Results
Nigeria

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.762521	49.06414	47.85613	0.0383
At most 1	0.605823	23.18597	29.79707	0.2371
At most 2	0.268531	6.428780	15.49471	0.6448
At most 3	0.043480	0.800166	3.841466	0.3710
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Ghana

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.706894	54.48030	47.85613	0.0105
At most 1 *	0.622822	32.39032	29.79707	0.0246
At most 2	0.437359	14.83965	15.49471	0.0626
At most 3 *	0.220663	4.487613	3.841466	0.0341
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Kenya

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.817194	59.16600	47.85613	0.0031
At most 1	0.700681	28.57805	29.79707	0.0686
At most 2	0.285379	6.865642	15.49471	0.5933
At most 3	0.044405	0.817589	3.841466	0.3659
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				

From table 6, for the three countries variables, each of the trace test indicates at least one co-integrating equation at 5% level for Nigeria and Kenya. But as for Ghana, it indicates 2 co-integrating equations. Therefore, the null hypothesis of no co-integration is rejected, but the alternative hypothesis is accepted. One may conclude that there is a long run relationship existing among the variables for each of the countries. Apart from VAR, we may run vector error correction model (VECM) using lag (1) (as suggested in the lag length criteria) for the study to obtain short run and long run coefficients. So, the Johansen Co-integration short run and long run estimates are presented in table 5 and 6 respectively.

Results of the Short Run VECM, 2000-2019

In this section, the results of the short run and long run VECM are presented. The estimation is for 2000-2019 and it is presented for having the largest observation. The results are discussed for each country in table 5 and 6.

Table 7: The Short Run VECM 2000-2019.

Variables	Nigeria		Ghana		Kenya	
	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
C	-0.4878 (0.7808)	-0.6247	-3.4017** (1.5020)	-2.2646	0.5517 (0.9865)	0.5592
IF	0.1219 (0.2680)	0.4549	0.1830 (0.2461)	0.7437	0.0270 (0.2607)	0.1038
MP	-0.5295 (0.3446)	-1.5367	0.2009 (0.4258)	0.4718	-0.3760 (0.2132)	-1.7634
GG	0.2247*** (0.0813)	2.7636	0.3651 (0.3820)	0.9557	-0.1320 (0.4181)	-0.3157
EX	0.0261 (0.0350)	0.7452	9.8741* (5.0211)	1.9664	-0.3291 (0.2357)	-1.3960
VEC	-0.3342* (0.1567)	-2.1324	-1.8913*** (0.4381)	-4.3166	-1.0478*** (0.3199)	3.2746

Source: Author's computation, E-Views 10.0

Statistics	Nigeria	Ghana	Kenya
R-squared	0.4638	0.7642	0.6756
Adjusted R2	0.2403	0.6659	0.5404
F-statistic	2.0760	7.7781	4.9983
Prob (F-stat)	0.0991	0.0017	0.0104

* Significant at 10%; ** Significant at 5%; *** Significant at 1%, ( ) standard error

The result of the VECM is presented in table 7. The VEC term (-0.3342), (-1.8913), and (-1.0478) are negative and significant at 10%, 1% and 1% for Nigeria, Ghana and Kenya respectively. In other words, the speed of adjustment towards equilibrium is 33.42% for Nigeria and over 100% for Ghana and Kenya. The Nigerian case indicates a slow speed of adjustment towards long run equilibrium while the cases of Ghana and Kenya indicates fast speed of adjustment towards equilibrium. This means that while there might be lag between policymaking and target variables in Nigeria, policy made may take quick effects on economic variables in Ghana and Kenya. However, there are few significant variables in the short run. In Nigeria, economic growth is significant at 1%, exchange rate is significant at 10% in Ghana, but no variable is significant in the short run in Kenya. Base on the result, Nigeria and Kenya do not satisfy the Taylor rule. A change in the central bank interest rate (MP) would lead to inflation rate changes in opposite direction as the coefficient for the two country is negative. However, in the case of Ghana, it appears inflation rate and interest rate

met the Taylor rule condition, inflation and interest rates move in the same direction. Nonetheless, this may be a likely occurrence probably in the long run because none of the variables is significant. Economic growth relative to inflation is positive and significant at 1% in Nigeria. It shows no trade-off as postulated by Taylor rule. A productive Nigerian economy might generate rise in inflation. This is possible if the macro economy is not strong enough to withstand external shocks often threatening developing countries.

The adjusted R-squared for Nigeria (24%) shows that the explanatory variables can only weakly determine the dependent variable. That is, MP, GG and EX can jointly explain the variation in inflation rate in the short run but rather insignificantly. Whereas, for Ghana and Kenya, the adjusted R-squared shows that the independent variables can strongly determine changes in inflation rate there by debunking Adebiyi (2009) and Adaramola and Dada (2020) findings for the Nigerian and Ghanaian economies. The F-statistics, as well as the R-squared, which show the goodness of fit of the models are significant at 10%, 1% and 5% for Nigeria, Ghana and Kenya. In addition, the Wald statistical tests also show that all the independent variables for each country, can jointly determine inflation rate in the short run.

Results of the Long run Estimation, 2000-2019

Table 8

Variables	Nigeria		Ghana		Kenya	
	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
C	10.1680*** (0.6188)	16.4306	14.1777*** (1.7872)	7.9328	8.6276*** (1.1544)	7.4736
IF	0.2306 (0.1764)	1.3075	-0.2696 (0.1878)	-1.4359	-0.0191 (0.2393)	-0.0798
MP	-0.2080 (0.2703)	-0.7696	0.9232 (0.5181)	1.7818	-0.1033 (0.2435)	-0.4241
GG	0.1237** (0.0561)	2.2052	-0.1649 (0.4264)	-0.3868	0.0174 (0.4605)	0.0379
EX	0.0417 (0.0278)	1.4969	-5.0148 (5.5150)	-0.9092	-0.4846 (0.2658)	-1.8225

Source: Author's computation, E-Views 10.0

Statistics	Nigeria	Ghana	Kenya
R-squared	0.4267	0.2418	0.2109
Adjusted R2	0.2504	0.0085	-0.0317
F-statistic	2.4196	1.0367	0.8690
Prob (F-stat)	0.1013	0.4252	0.5082

* Significant at 10%; ** Significant at 5%; *** Significant at 1% ( ) standard error

In the long run, as displayed in table 6, apart from GG for the Nigerian economy and significant at 5%, all other coefficients are not significant. This means that the variables are not necessarily jointly suitable for long run policy instruments. In other words, the variables are short run policy instruments. In addition, the R-squared weak value shows that the explanatory variables are unable to strongly determine the variations in each of the dependent variables in all the three countries. Also, the probability F-statistics are not significant at 10%, representing the fact that the variables in the model might are not be valid for long run policy. Monetary policy rate (MP) which is the target variable to address inflation rate is not significant in the long run for all the selected countries. In the case of Ghana, in the long run, MP and interest rate seem to meet the Taylor rule condition because of the positive relationship between the two variables. In 2009, Adebiyi had found that Nigerian and Ghanaian economies are not sound enough to practice the Taylor rule.

From this point, the next analysis is the impulse response a variance decomposition. These are presented below.

Impulse Response Function

It is necessary to find the short run relationship between inflation rate and monetary policy rate as well as other exogenous variables in terms of responses to shocks. Impulse responses identify responsiveness of the endogenous variable in a VAR model when a shock is exerted on the error terms in the regression equation. Similar shocks is realizable in VECM. A unit shock is applied to each variable to realize the effect in VAR system. That is, one standard deviation positive shock is applied to the VAR residual to see how it affects the whole VAR model. The study recognizes the conduct of proper ordering of the variable through the Cholesky adjustment method.

Table 9: Impulse Response Function, 2000-2019

Response of IF:

	Nigeria				Ghana				Kenya			
Period	**IF**	**MP**	**GG**	**EX**	**IF**	**MP**	**GG**	**EX**	**IF**	**MP**	**GG**	**EX**
1	2.752	0.000	0.000	0.000	4.112	0.000	0.000	0.000	3.907	0.000	0.000	0.000
2	1.914	-0.53	0.365	0.184	1.015	2.700	-1.61	0.961	-0.06	0.988	1.381	-2.43
3	1.748	-0.03	-1.34	0.042	1.714	2.332	-1.18	-0.52	0.099	0.367	0.867	-0.96
4	1.563	0.789	-1.41	-0.16	0.780	2.906	-1.4	-0.52	1.617	0.157	0.525	-0.48
5	1.829	0.665	-0.92	-0.16	1.183	2.636	-1.18	-0.91	0.955	0.502	0.862	-1.25
6	1.959	0.215	-0.31	-0.04	0.981	2.778	-1.24	-0.78	0.607	0.431	0.870	-1.12
7	1.924	-0.02	-0.47	0.030	1.138	2.689	-1.18	-0.84	1.015	0.329	0.727	-0.87
8	1.785	0.185	-0.85	-0.02	1.072	2.740	-1.21	-0.78	0.990	0.393	0.784	-1.02
9	1.755	0.422	-1	-0.08	1.115	2.715	-1.2	-0.8	0.836	0.411	0.817	-1.06
10	1.816	0.427	-0.81	-0.09	1.090	2.732	-1.21	-0.79	0.908	0.377	0.782	-0.98

Source: Author's computation, E-Views 10.0

Table 9 shows that in Nigeria, inflation rate has a high positive response to own shocks. Similar response is recorded in Ghana. In Kenya, the response is weak in most of the periods but negative in the 2nd period. The contemporaneous responses of inflation to one standard deviation shock to monetary policy rate is positive in Kenya but weak. It is weak also in Nigeria but negative in the 2nd, 3rd and 7th periods. However, in Ghana, the responses is strong and positive. This substantiates the fact that Ghana's case may adopt Taylor rule, that is, interest rate and inflation rate move in the same direction. Interest rate can be used to adjust inflation rate. Inflation rate has negative response to shocks to economic growth in Nigeria and Ghana. The response is significantly strong in Ghana. That is GG policy can help reduce inflationary pressure in the two countries. In Kenya, the response of inflation rate to economic growth is positive but weak. That is for Kenya, a policy to increase economic production may have little effect on inflation rate. Responses of inflation rate to one standard deviation shock to exchange rate is strong for Kenya but weak in Nigeria and Ghana. Exchange rate policy may not necessarily affect inflation rate in Nigeria and Ghana. This debunk the findings of some authors that exchange rate is significant in determining inflation rate in Nigeria and Ghana.

In summary, it can be deduced from the impulse response function that monetary policy rate, which stands as the bedrock for other interest rates may be a plausible policy instrument to for inflation targeting in Ghana. It then follow logically that Ghanaian economy might be sound enough to adopt inflation targeting. Also, Kenya also has positive but relatively weak response, one may conclude that for the Kenyan

economy over time, interest rate can also be a key instrument for inflation targeting. The case of Nigeria is ambiguous. Findings of this study reveals a weak and ambiguous relationship between interest rate (MP) and inflation rate in the short run, but the influence of interest rate tend to increase positively in the long run. Response to exchange rate is neutral while economic growth appears to be worsening inflation rate. Therefore, the Nigerian economy need significant overhauling. As far as monetary policy is concerned, the central banks of the three selected countries need an efficient management of macro economy via prudential monetary policymaking.

Variance Decomposition

The next analysis is to measure the degree of variation caused by a particular variable to another. This is indicated by the variance decomposition. The forecast error variance decomposition reveals the proportional contribution of policy shocks to variations in a given macro-economic variable. The greater the proportion of variation attributable to a given policy variable, the more important is the variable in the policymaking and also as a policy instrument. While variance decomposition may reveal the importance of a policy variable to movement in a macro variable, the direction or extent of these movements can only be detected in the impulse responses, (Adebiyi and Lawanson, 2006); (Fakiyesi and Adebiyi, 2012).

Table 10: Variance Decomposition, 2000-2019

Variance Decomposition of IF:

	Nigeria				Ghana				Kenya			
Period	**IF**	**MP**	**GG**	**EX**	**IF**	**MP**	**GG**	**EX**	**IF**	**MP**	**GG**	**EX**
1	2.752	0.000	0.000	0.000	4.112	0.000	0.000	0.000	3.907	0.000	0.000	0.000
2	1.914	-0.53	0.365	0.184	1.015	2.700	-1.61	0.961	-0.06	0.988	1.381	-2.43
3	1.748	-0.03	-1.34	0.042	1.714	2.332	-1.18	-0.52	0.099	0.367	0.867	-0.96
4	1.563	0.789	-1.41	-0.16	0.780	2.906	-1.4	-0.52	1.617	0.157	0.525	-0.48
5	1.829	0.665	-0.92	-0.16	1.183	2.636	-1.18	-0.91	0.955	0.502	0.862	-1.25
6	1.959	0.215	-0.31	-0.04	0.981	2.778	-1.24	-0.78	0.607	0.431	0.870	-1.12
7	1.924	-0.02	-0.47	0.030	1.138	2.689	-1.18	-0.84	1.015	0.329	0.727	-0.87
8	1.785	0.185	-0.85	-0.02	1.072	2.740	-1.21	-0.78	0.990	0.393	0.784	-1.02
9	1.755	0.422	-1	-0.08	1.115	2.715	-1.2	-0.8	0.836	0.411	0.817	-1.06
10	1.816	0.427	-0.81	-0.09	1.090	2.732	-1.21	-0.79	0.908	0.377	0.782	-0.98

Source: Author's computation, E-Views 10.0

From table 10, for the Nigerian economy, own shocks constitute significant source of variation to inflation rate forecast errors decomposition ranging from 79.91% to

100%. For the Nigerian economy, curbing future inflation rate will require limiting current rate of inflation which may demand efficient transmission channel between interest rate and inflation rate in the current and next periods. Economic growth also play a role while monetary policy rate and exchange rate play no noticeable role. In Kenya, apart from own shocks, economic growth and exchange rate also play noticeable role in variation in error in inflation rate. However, in Ghana, monetary policy rate paly significant role in forecast error decomposition in inflation rate ranging from 57.24% to 25.35%. In addition, the variation tends to rise in the long run. In other words, monetary policy rate is a key policy instrument to address variation in inflation rate in Ghana. Economic growth rises gradually to some extent. A shock to it might also have some degree of variations in inflation.

Sensitivity Analysis

Coefficient and Residual Diagnostic Tests

Table 11: Wald Statistical Test for Short and Long Run Co-integration Estimation (2000-2019) for the Nigerian Economy.

Wald Test, Short Run			
Test Statistic	Value	Df	Probability
F-statistic	3.288023	(3, 12)	0.0582
Chi-square	9.864070	3	0.0198
Null Hypothesis: C(3)=C(4)=C(5)=0			

Wald Test: Long Run			
Test Statistic	Value	Df	Probability
F-statistic	1.716878	(3, 13)	0.2127
Chi-square	5.150634	3	0.1611
Null Hypothesis: C(2)=C(3)=C(4)=C(5)			

The Wald statistical test is presented in table 9. The null hypothesis is rejected based on the Chi-square statistics which is significant at 5% level and conclude that the explanatory variables can jointly Granger cause inflation rate in the short run. For the long run, the null hypothesis is accepted based on the Chi-square statistics which is not significant at 5% level and conclude that the explanatory variables cannot jointly Granger cause or determine inflation rate in the long run.

Table 12: Wald Statistical Test for Short and Long Run Co-integration Estimation (2000 -2019) for the Ghanaian Economy.

Wald Test, Short Run

Test Statistic	Value	Df	Probability
F-statistic	1.675364	(3, 12)	0.2249
Chi-square	5.026092	3	0.1699
Null Hypothesis: C(2)=C(3)=C(4)=C(5)			

Wald Test, Long Run			
Test Statistic	Value	df	Probability
F-statistic	1.342408	(3, 13)	0.3035
Chi-square	4.027224	3	0.2585
Null Hypothesis: C(2)=C(3)=C(4)=C(5)			

From table 12, in the cases of short and long run for Ghana, the null hypothesis is accepted based on the Chi-square statistics which is not significant at 5% level and conclude that the explanatory variables cannot jointly Granger cause or determine inflation rate in the long run.

Table 13: Wald Statistical Test for Short and Long Run Co-integration Estimation (2000 -2019) for the Kenyan Economy.

Wald Test, Short Run

Test Statistic	Value	Df	Probability
F-statistic	0.711851	(3, 12)	0.5634
Chi-square	2.135552	3	0.5448
Null Hypothesis: C(2)=C(3)=C(4)=C(5)			

Wald Test, Long Run

Test Statistic	Value	df	Probability
F-statistic	1.720084	(3, 13)	0.2120
Chi-square	5.160253	3	0.1604
Null Hypothesis: C(2)=C(3)=C(4)=C(5)			

Also, for the Kenyan economy in table 13, in the cases of short and long run Wald test, the null hypothesis is accepted based on the Chi-square statistics which is not significant at 5% level and conclude that the explanatory variables cannot jointly Granger cause or determine inflation rate.

Table 14 VECM Residual Normality Tests

Statistics	Nigeria	Ghana	Kenya
Joint Chi-sq	3.5471	7.9818	4.5521
Joint Prob	0.4707	0.0922	0.3364

From table 14, for Ghana, the null hypothesis is rejected and the alternative hypothesis is accepted and it is concluded that the residual is normally distributed. However, in the case of Nigeria and Kenya, it appears the residuals of the model are not normally distributed as displayed by the chi-square statistics which is not significant at 5%.

Table 15: VECM Residual Heteroscedasticity Tests (Levels and Sqares)

Statistics	Nigeria	Ghana	Kenya
Chi-sq	106.49	97.687	103.79
Df	100.00	100.00	100.00
Prob	0.3096	0.5468	0.3776

From table 15, the alternative hypothesis is accepted. The conclusion is that the residuals of the models for the three countries are normally distributed as displayed by the chi-square statistics.

CONCLUSION AND RECOMMENDATIONS

This study examines the Taylor rule and monetary policymaking in the sub-Saharan African countries. We select Nigeria, Ghana and Kenya as representatives of the region because the three countries appear to have more vibrant economies compared to others in the region. For instance, they are high income countries and most developed in the SSA. Except Nigeria which still trailed behind, Ghana and Kenya are both in the medium level of human development index. The Taylor rule assumes a positive relationship between interest rate and inflation rate, in other words, when inflation rate is high, interest rate can be raised to reduce or at least to keep inflation rate stable. This hypothesis has been empirically tested by Wu and Xia (2016) for the US economy. It has also been identified by Bernanke (2020) for the US economy. Adebiyi (2009) findings, based on Taylor rule, revealed that Nigerian and Ghana were not yet ready for inflation targeting via interest rate adjustment. In this study, it is found that inflation targeting might be good for the Ghanaian economy, and Nigeria, to some extent, but Kenya is not yet ready at least in the short run.

However, based on descriptive statistics, Kenyan economy appears to perform better than Nigeria and Ghana. In other words, Kenya might possess a better rule or monetary policy stance not identified in this study. But on a general note, previous research findings show that most countries in SSA have attempted to curb high inflation rate by adjusting interest rate, exchange rate and economic production. In addition, this study findings reveal that responses of inflation rate to shocks from exchange rate and economic growth are weak and they might not be good policy instruments to address inflation rate. Nevertheless, it is established that Ghana may be ready now for inflation targeting and Nigeria too if the macroeconomic framework is made stable and reliable. Therefore, it is highly recommended that whether Taylor rule or not, a stable macro economy is essential for any monetary policymaking in any 21st century economy. A stable macroeconomic framework is prerequisite where inflation and interest rates are both single digits and where it is possible for policy makers to identify early sign of economic poor performance and are able to make possible adjustment.

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