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Macro-Economic Variables Determining Stochastic Volatility of The Zambian Currency

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Abstract— **In this paper, we assess the macro-economic determinants of the stochastic volatility of the Zambian currency over time. The research was motivated by the debates revolving around the depreciation of the Zambian currency against major foreign currencies, which are mainly characterized by a lack of empirical analysis and evidence of the factors influencing the volatility of the currency. We determine the correlation between the Zambian foreign currency exchange rate and the macro-economic variables including inflation, interest rate, foreign direct investment and external debt; and forecast the volatility of the Zambian currency based on the historical data. Our results show a statistically significant relationship between the exchange rate of the Zambian currency and the macro-economic indicators at a 95 percent level of confidence. In this respect, the Zambian foreign currency exchange rate is found to be highly sensitive to external debt and foreign direct investment net inflows.**

Index Terms— **Macro-Economic Determinants, Stochastic Volatility.**

I. INTRODUCTION

Zambia floats its currency on the international money market using a variable exchange rate that is determined by market forces. The foreign exchange rate is one of the most important means through which a country's relative level of economic health is determined [10]. It may fluctuate daily with the changing market forces of demand for and supply of currencies from one country to another. Zambia experienced rapid depreciation against major foreign currencies in 2015. This led to His Excellency, the President of the Republic of Zambia, Mr. Edgar Chagwa Lungu, to make pronouncements on the volatility of the Kwacha. The President explained that the country remained vulnerable to developments in the global economy as the United States Dollar unprecedentedly strengthened against other currencies including the Kwacha, and the depreciation of the Kwacha was largely accelerated by the trade imbalances the country was experiencing as the imports were in excess of the exports. It was observed that the increased volatility of the Zambian Kwacha appeared to reflect market panic more than underlying fundamentals. To this effect, the Minister of Finance was directed to work closely with the Central Bank to assess additional market intervention measures to address the observed excessive volatility. In this regard, this research provides the answers to the scientific and policy debates on the causal links between volatility of the Zambian Kwacha and the macro-economic indicators of the economy. Volatility is a fundamental concept to the discipline of mathematical finance because it is used to determine the probability of bankruptcy and the liquidity of stock markets for the purpose of financial risk management [12], [13], [14], [15] and [16]. Conventional economic theory [4] suggests that consumers tend to avert risk and behave in such a manner as to reduce the level of participation in an economic activity that is associated with high risks. [8] exemplified this theory by explaining that when asset prices fluctuate sharply over time, investors may lose confidence in capital markets resulting in reduced flow of capital into equity markets. This may induce regulatory agencies and providers of capital to force firms to allocate a larger percentage of available capital to cash equivalent investments, which affects the allocation efficiency in the economy [18] and [21]. There are several factors influencing the variability of foreign exchange rates. [2] found that exchange rate and current account have direct and positive relationship with inflation and both exchange rate and current account are the key factors that badly affect the small economies like Zambia. [11] investigated the dynamic association between exchange rate regimes, capital flows and currency crisis in emerging economies. His study draws on lessons learned during the 1990s, and deals with some of the most important policy controversies that emerged after the Mexican, East Asian, Russian and Brazilian went through calamity of higher exchange rate as it is for Zambia. He concluded that under the appropriate conditions and policies, floating exchange rates can be effective and efficient.

Exchange rate volatility has mostly been studied for its impact on economic growth factors. [3] considered the impact of exchange rate volatility on the labour market. In their case, the exchange rate volatility was measured as the standard deviation of the 12 month-to-month changes in the logarithm of the spot rate. [9] and [20] studied the effect of exchange rate volatility on bilateral trade flows. They used

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the standard deviation of the first difference of the logarithmic exchange rate as well, but also employed two other measures-the sum of the squares of the forward errors and the percentage difference between the maximum and minimum nominal spot rate. Other studies, such as [5], [7], [18], [19] and [20] modelled the exchange rate volatility as the moving sample standard deviation of the growth rate of the real exchange rate. On the other hand, [2] analyzed the impact of exchange rate volatility on the volume of bilateral exports, and [6] investigating the influence of exchange rate volatility on real exports and applied the GARCH model for measuring volatility.

II. THE MODEL

This paper formulates an empirical model of the volatility of the Zambian currency in the foreign exchange market based on the monetary theory that postulates that the current exchange rate is determined by current fundamental economic variables. Thus, this paper assumes that there is a positive correlation between exchange rate and the macro-economic variables including the interest rate, inflation rate, external debt, foreign direct investment among other factors as illustrated in Figure 1.

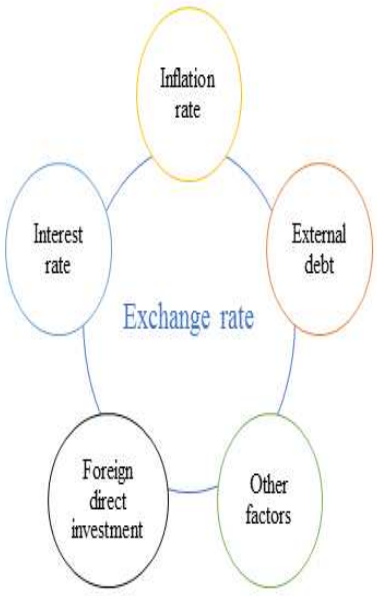

Figure 1: *Exchange rate and its macro-economic determinants*

The exchange rate is modelled as a function of macro-economic variables as specified by (1) below;

$$Exchange\ rate = \{FDI, ITR, INF, EXD\} \quad (1)$$

Where, FDI is foreign direct investment; ITR is interest rate; INF is inflation rate; and EXD is external debt.

The financial econometric model is then estimated by (2) in which β is the coefficient of determination and ε is the error term.

$$Exchange\ rate = \beta_0 + \beta_1 FDI + \beta_2 ITR + \beta_3 INF + \beta_4 EXD + \varepsilon \quad (2)$$

The model assumes that:

1) There is a linear relationship between the exchange rate and the macro-economic variables.
2) The macro-economic variables are non-stochastic
3) The expectation of the error term is zero

III. RESULTS AND DISCUSSION

The time series plots of exchange rates, foreign direct investment, interest rates, inflation rates and external debt are presented in Figure 2. As can be seen from the graphs, there is generally an increasing trend in exchange rates, foreign direct investment and external debt, while a decreasing trend exist in the interest and inflation rates.

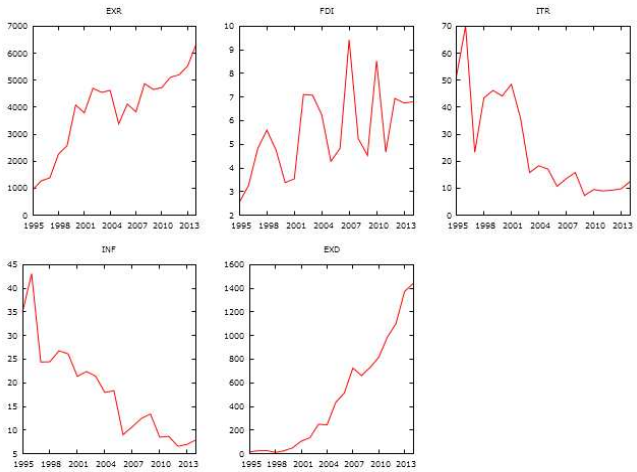

Figure 2*: Exchange rates, foreign direct investment, interest rates, inflation rate and external debt for Zambia: 1995-2014*

The descriptive statistics of the data series are further summarized and presented in Table 2. Among the variables, the external debt and interest rate have the highest fluctuation with a coefficient of variation of 0.977 and 0.729 respectively.

***Table 1**: Summary statistics of the time series data*

Variable	Mean	Median	Minimum	Maximum
EXR	3895.56	4332.94	937.780	6330.00
FDI	5.51700	5.03500	2.55000	9.42000
ITR	25.5750	16.4500	7.30000	70.0000
INF	18.2710	18.1500	6.58000	43.1000
EXD	483.284	341.755	11.2200	1440.28
Variable	**Std. Dev.**	**C.V.**	**Skewness**	**Ex. Kurtosis**
EXR	1491.72	0.382928	-0.662629	-0.496940
FDI	1.80976	0.328033	0.384895	-0.518599
ITR	18.6510	0.729266	0.880499	-0.460042
INF	9.99876	0.547247	0.761893	0.0233803
EXD	472.352	0.977381	0.673198	-0.774342

The Financial Econometric Model

Using the Ordinary Least Squares (OLS) method, the financial econometric model is estimated using equation (3) in which the numerical values in parentheses are the estimated errors of the regression. For the 20 observations, the coefficients of determination is 71.3% for the R-squared and 63.7% for the adjusted R-squared (See Regression Output). This shows that the data fitted very well to the regression line.

EXR = 4.84e+03 + 58.4*FDI + 16.3*ITR - 113*INF + 0.797*EXD (3)

(1.53e+03) (145) (27.2) (62.3) (0.798)

The financial econometric model shows positive correlation between exchange rate and all the variables except for the inflation rate. This means that the inflation rate is not significantly influencing the exchange rate. The most significant factors influencing the exchange rate is the external debt and foreign direct investment, inducing 79.7 and 58.4 percentage changes, respectively, in the response variable.

The analysis of variance of the regression shows statistical significance at 5% level as the computed F-statistic (0.00054) was less than the p-value (0.005). Thus, the model could be used to predict future values of exchange rates with 95% confidence.

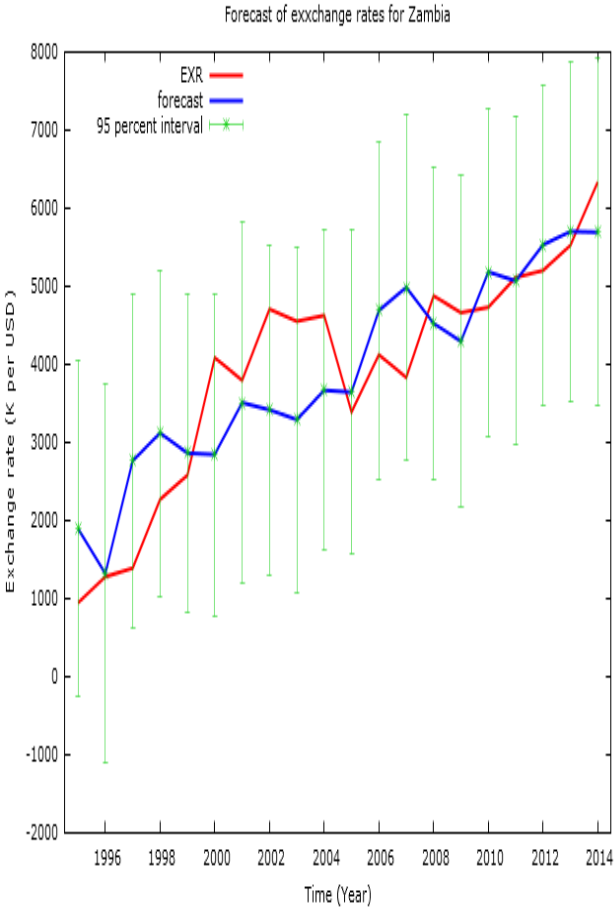

***Figure 3**: Exchange rate forecast for Zambia*

REGRESSION OUTPUT

Regression Statistics	
Multiple R	0.84449
R Square	0.71317
Adjusted R Square	0.63668
Standard Error	899.146
Observations	20

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	30152362.1	7538091	9.32398	0.000543084
Residual	15	12126944.2	808463		
Total	19	42279306.3			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95.0%*
Intercept	4839.1	1528.47627	3.16597	0.00639	1581.234801	8096.974886
FDI	58.4198	144.511056	0.40426	0.69173	-249.5982645	366.4377848
ITR	16.3004	27.2326738	0.59856	0.5584	-41.74463796	74.34550257
INF	-113.18	62.2696557	-1.8176	0.08915	-245.9053073	19.54395148
EXD	0.79704	0.79807903	0.9987	0.33378	-0.904020703	2.498109679

IV. DISCUSSION

The results presents a significant relationship between the exchange rate of the Zambian currency and the macro-economic indicators. The findings in this research are comparable to [1], [8] and [17]. In this respect, Zambia's foreign currency exchange rate is highly sensitive to external debt and foreign direct investment net inflows. This has implications for the fiscal policy implementation and management in Zambia. The country relies on external borrowing to finance capital-intensive programmes with a view to stimulating economic growth and development. However, excessive borrowing exerts a huge financial burden on the economy to the effect that the cost of borrowing depreciates the currency against major foreign currencies. At the same time, economic policy is directed at creating an enabling environment for foreign direct investment in the key sectors of the economy. This is often linked to employment creation, which is an indicator of economic development. We note that reduced net inflows of foreign direct investment result in massive job losses and speculative economic behavior that fuel up the exchange rate, and consequently the inflation rate. This was typical of the Zambian situation in 2015 during which the volatility of the Kwacha caused the inflation rate to reach as high as 21%. Our results are consistent with dynamic forecast of the future volatility of the exchange rate using stochastic models such as the GARCH models.

V. CONCLUSION

The exchange rate for Zambia is positively correlated with foreign direct investment, interest rate and the external debt, but is negatively correlated with the inflation rate. We find that, foreign direct investment and external debt are the key determinants of the volatility of the Zambian currency and therefore recommended that Zambia should not only provide an enabling environment for foreign direct investment to stimulate economic growth, but also engage in fiscal policy measures that should reduce the cost of borrowing in order to ensure a stable macro-economic environment.

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