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An empirical investigation on dollarization and currency devaluation: A case study of Tanzania

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An empirical investigation on dollarization and currency devaluation: a case study of Tanzania

Zakia Musoke

Abstract

The debate regarding the usage of domestic currency versus dollarizing an economy is still robust in many developing countries. Dollarizing an economy commonly entails dollarizing bank deposits and loans, transacting in dollars and tagging prices of goods and services in dollar. In Tanzania, commercial banks have the power to open foreign currency deposit accounts for any account holder, giving them the freedom to hold foreign currency and pay in foreign currency. Due to the strength of foreign currencies over the domestic shilling, investors prefer to hold bank accounts in foreign currencies preferably USD. This paper's main focus is dollarization and currency devaluation; of which are yet unresolved both theoretically and empirically. Using monthly nominal exchange rate data for the study period 2000–2014, the author introduced GARCH models to examine the relationship between dollarization and exchange rate. The Autoregressive Conditional Heteroscedasticity models indicate that dollarization does indeed induce currency depreciation as well as exchange rate volatility. Based on the findings and conclusions from other literature, this paper also proposes measures on how the country can prevent or offset the negative impacts of dollarization.

JEL C8 E5 E41

Keywords Dollarization; currency devaluation; GARCH; exchange rates

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1. INTRODUCTION

1.1 Significance of the Topic

Dollarization is an economic tool that is recommended to developing economies to help achieve credibility, growth and prosperity. In most cases, this has failed as evident in some Latin American countries, which have been unable to engage in macroeconomic management. Dollarization has been evident to undermine monetary sovereignty and cause loss of autonomous monetary policy. Thus, this paper seeks to create awareness about the impact of dollarization upon the economy and domestic currency.

Price instability in developing countries and experienced financial crisis in emerging economies has generated a number of debates on economic reforms and monetary policies. In some countries dollarization has been the outcome of official government policy. This has raised a lot of concerns to academicians, policy makers and researchers, resulting in a number of proposals for reforming their economy by giving up their currencies to adopt an advanced nation's currency as legal tender. This proposal known as dollarization has been advocated by a few but very influential group of economists making it a real policy option.

1.2 Background of the problem

Tanzania is one of the historical socialist countries. In the beginning of 1986, the government introduced several adjustment programs to dismantle the socialist economic controls, one being to depreciate the overvalued exchange rate and free interest rates, committing it to improving the investment climate. Many policy changes have been implemented including redrawing tax codes, floating the exchange rate, licensing foreign banks and creating an investment promotion center to reduce difficulties for investors. Since the reform dollarization has gained ground in the economy.

A partial outcome of the economic restructuring has given Tanzanian residents the freedom to hold foreign currency and also pay in foreign currency. As part of the financial sector reforms, in the year 1992 an amendment was made allowing commercial banks to open foreign currency deposits to both residents and non-residents. Given the strength of foreign currencies over the domestic shilling, investors prefer to hold bank accounts in foreign currencies preferably USD. In addition, most imported goods and services are pegged to the US Dollar. This increases the preference for and demand for USD, simultaneously the value of the domestic currency has been depreciating from 8.21 TZS/USD in 1980 to 2,162 TZS/USD as of late 2015.

2. LITERATURE REVIEW

2.1 What is Dollarization

Dollarization is a situation in which a foreign currency is (often the U.S. Dollar) replaces a country's currency in performing several functions of money. Ortiz (1983) defined dollarization as the widespread of U.S Dollar for transaction purpose in Mexico. Dollarization can be of two types, official (or *de jure*) of which implies that the economy has completely given up their domestic currency and is using a foreign currency as a medium of exchange; example Zimbabwe. The other is unofficial (or *de facto*) dollarization that implies a foreign currency is used as a substitute means of exchange alongside the domestic currency. Many countries including Tanzania fall into this group.

Several studies have attempted to address the shortcomings of dollarization but explicitly focus on the transaction costs underlying currency substitution such as the research by Guidotti and Rodriguez (1992) that developed a cash-in-advance model which still left unexplained the source of the assumed transactions costs. After the crisis of 1998 in Southeast Asia and the Argentinean crisis in 2001/2002, most literature has turned attention to dollarization as the use of dollar as a currency denominating foreign debts; liability dollarization.

2.2 Theoretical Framework

Dollarization has long been central to the concerns of international economists, politicians and policymakers. In early 2002 this debate became more intense after the fall of the Argentina's currency board. Barry Eichengreen of University of California in Berkeley pointed out that nations with malfunctioning banking systems, budgets and labor markets will perform miserably whether they retain their currency or dollarize.

Whilst Dollarization is no longer a new phenomenon, semi-official dollarization (*de facto dollarization*) is gaining momentum in many developing countries. Most literature suggests that dollarization is mainly driven by countries' need to protect the value of their wealth and income from being eroded by increasing inflation rates and currency depreciations. However, this concept does not hold in Tanzania as the country's inflation rate is unchangeable despite dollarization and the currency is being highly affected with increased dollarization.

Dollarization has gained ground in Tanzania since the initiation of economic liberalization from central planned to market based economy in early 90's. This has raised great concerns among policy makers in the country and general public. The main focus of this study is on the relationship between dollarization and exchange rate movements in Tanzania. Although some literature on currency

substitution mention that dollarization enhances financial stability (Ricardo Hausmann 1999) pointing out that currency and maturity mismatch in financial markets reflects distrust of the national currency; many other literature emphasize that dollarization could be a major source of exchange rate instability. Gorton and Roper (1981), Akcay et al. (1997), and Corrado (2008) demonstrate that exchange rate instability increased with the increase of the degree of currency substitution.

Research on dollarization is not new or uncommon but there is little or no discussion about the relationship between currency depreciation and dollarization. Using Tanzania as a case study (for its ongoing depreciation) this study will examine this relationship and its impact on monetary policy.

3. EMPIRICAL ANALYSIS

3.1 Measurements of Dollarization

Previous researchers have conceptualized the degree of which unofficial dollarization is to be measured. Unofficial dollarization can be measured in terms of foreign currency in circulation (FCC), foreign currency deposits (FCD) held by residents in the domestic banks and offshore depository accounts held by domestic residents (OSD).

The most widely used measurement of dollarization; Dollarization Index (DI) is expressed as the ratio of foreign currency deposits (FCD) to broad money (M2) [\[Figures 3,4\]](#). Foreign currency deposits are hereby considered as an approximate total of foreign currency holdings (foreign currency in circulation, foreign currency time deposits and demand deposits as well as offshore deposits held by domestic residents (see, e.g., Clements & Schwartz, 1993, Yinusa, 2008).

3.2 Data

The paper aims at presenting the effect of dollarization to the Tanzanian's currency fluctuations using monthly data from January 2000 to December 2014 (180 observations) [\[Figure 1\]](#). The data on foreign currency deposits (FCD) is readily available from the Tanzania Central Bank (BOT) statistics-depository corporation survey; that are released on a quarterly basis. The data on foreign currency in circulation (FCC) is difficult to obtain as there is no institution that is responsible or rather willing to provide. Several literatures have attempted to estimate the value of FCC providing merely satisfactory but paltry results. Despite the fact that the Foreign exchange act requires that Tanzanians apply for a permit before they can open an offshore account, there have been numerous cases of disregard for the act thus making the data on offshore deposits unreliable. Therefore leaving foreign currency deposits (FCD) as the reliable measure for foreign currency denominated assets.

To capture a wider spectrum of the foreign currency holdings we decided to include interest rate (deposit rate) in our model. By doing so we are able to address the common argument that deposit interest rate is a key factor behind dollarization of deposits (see Henrique S. Basso, Oscar Calvo-Gonzalez & Marius Jurgilas). The data on deposit interest rate is obtained from the International Financial Statistics of the International Monetary Fund (IMF)[\[Figure 2\]](#)

3.3 Lag selection

In modeling financial information, the need for proper selection of a suitable model is crucial in understanding the structure and hence better forecasting. Akaike (1973); a model should be evaluated on the basis of good results when it is used for predictions. Several methods have emerged popularity but only two have been commonly used; Akaike Information criterion (AIC) and Schwarz Information Criterion (AIC). Based on the study by Farrukh Javed and Panagiotis Mantalos, the implicit suggestion is that AIC performs well under small sample size while SIC provides better results for larger sample size. Therefore SIC is the most appropriate criterion for lag length selection in our study. [\[Table 1\]](#)

3.4 Data Analysis

The paper applies three conditional distributions for the standardized residuals of exchange rates; Gaussian, student's t , and the generalized error distribution (GED). The key parameters $(\alpha, \gamma, \omega, \theta, \delta, \beta)$ are obtained from the maximization of the log likelihood function:

$$\log L = \sum_{t=1}^T l_t = -\frac{T}{2} \log[2\pi] - \frac{1}{2} \sum_{t=1}^T \log \sigma_t^2 - \frac{1}{2} \sum_{t=1}^T \frac{\epsilon_t^2}{\sigma_t^2} \quad (1)$$

Whereas T is the sample size, and

$$l_t = -\frac{1}{2} \log[2\pi] - \frac{1}{2} \log[\sigma_t^2] - \frac{1}{2} \frac{[y_t - x'_{t-1}\beta]^2}{\sigma_t^2} \quad (2)$$

For student's t distribution, log likelihood contributions are assumed to be the form of:

$$l_t = -\frac{1}{2} \log \left[\frac{\pi[v-2]\tau[v/2]^2}{\tau[(v+1)/2]^2} \right] - \frac{1}{2} \log[\sigma_t^2] - \frac{(v+1)}{2} \log \left[1 + \frac{[y_t - x'_t\beta]^2}{\sigma_t^2[v-2]} \right] \quad (3)$$

Where σ^2 is the variance at time t , and the degree of freedom $v > 2$ controlling the behavior. The t -distribution approximates the normal as v approaches infinite ($v \rightarrow \infty$).

The GED is a normal distribution if $r = 2$ and fat tailed if $r < 2$.

$$l_t = -\frac{1}{2} \log \left[\frac{\tau \left[\frac{1}{r} \right]^3}{\tau [3/r] [r/2]^2} \right] - \frac{1}{2} \log \sigma_t^2 - \left[\frac{\tau \left[\frac{3}{r} \right] [y_t - x_t' \beta]^2}{\sigma_t^2 \tau \left[\frac{1}{r} \right]} \right]^{\frac{r}{2}} \quad (4)$$

3.5 Unit root test

Before applying the generalized autoregressive conditional heteroscedasticity (GARCH) and the Exponential generalized autoregressive conditional heteroscedasticity (E-GARCH), we should first determine whether or not each variable is stationary. Using the Augmented Dickey Fuller test (ADF) and the Phillip-Peron test (PP) we determine the order of integration of the variables.

ADF test is based on the following regression:

$$\Delta y_t = \varphi + \gamma t + \alpha y_{t-1} + \sum_{i=1}^k d_i \Delta y_{t-1} + \epsilon_t \quad (5)$$

where ϵ_t is an error term and $\Delta y_t, \Delta y_{t-1}$ are dependent variable autoregressors ($\Delta y_t = y_{t-1} - y_{t-2}$)

The Phillips-Peron test is based on the following regression

$$y_t = \rho_t + \beta y_{t-1} + \beta_1 \Delta y_{t-1} + \sum_{i=p}^t \beta_p \Delta y_{t-p} + \epsilon_t \quad (6)$$

where ρ_t may be zero or the sum of $\varphi + \gamma t$

3.6 The Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Model

The GARCH model approaches to identify how dollarization can influence the exchange rate movements. The GARCH model was initially introduced by Bollerslev (1986) and Taylor (1986) as a generalized version of Engle's (1982) Autoregressive Conditional Heteroscedasticity (ARCH). The GARCH (p,q) model suggests the conditional variance of returns is a linear function of lagged conditional variance terms and past squared error terms.

The standard GARCH (p,q) model specification can be expressed as follows:

$$Y_t = X_t \beta + \epsilon_t, \text{ where } t=1, 2, \dots, T, \epsilon_t \sim N(0; \sigma_t^2) \quad (7)$$

$$\sigma_t^2 = \omega + \sum_{i=1}^p \alpha_i \varepsilon_{t-1}^2 + \sum_{j=1}^q \gamma_j \sigma_{t-j}^2 \quad (8)$$

Whereas equation (7) represents the mean equation with an error term ε_t that satisfies $\varepsilon_t = v_t \sqrt{h_t}$ where v_t is a white-noise with $\sigma_v^2 = 1$. The variance equation given in (8) is a one-period ahead forecast variance based on past information; conditional variance with ω being the constant term, ε_{t-1}^2 the ARCH term and σ_{t-j}^2 the GARCH term following the constraints $\omega > 0, \alpha_i \geq 0, \gamma_j \geq 0$ so as to ensure that σ_t^2 is strictly positive. Incorporating our study variables into the model, the dependent variable; the log difference of nominal exchange rate (DLNER) and the independent variables being autoregressive of DLNER, the difference of dollarization Index DDI and the difference in interest rate DIR, respectively our GARCH model can also be written as:

$$\sigma_t^2 = \omega + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^q \gamma_j \sigma_{t-j}^2 + \delta_1 DDI + \delta_2 DIR \quad (9)$$

Where δ_1, δ_2 determines the impact of dollarization and interest rate on exchange rate volatility respectively.

3.7 The Exponential Garch (EGARCH) model

Unlike GARCH (p,q), EGARCH(p,q) model advanced by Nelson (1991) it incorporates asymmetric effects in returns from speculative prices, thereby removing the need for restrictions on the parameters to ensure positive conditional variance. EGARCH (p,q) can be expressed as:

$$\ln(\sigma_t^2) = \omega + \sum_{i=1}^p \alpha_i g(z_{t-1}) + \sum_{j=1}^q \gamma_j \ln(\sigma_{t-1}^2) \quad (10)$$

$$g(z_{t-1}) = \theta z_{t-1} + \beta [|z_{t-1}| - E|z_{t-1}|] \quad \text{where } z_t = \varepsilon_t / \sqrt{\sigma_t^2} \quad (11)$$

Where $g(z_{t-1})$ is linear at Z_t with a slope coefficient of $\theta + \beta$ also known as a dependent white noise with zero mean and unit variance. The volatility σ_t^2 can never be negative. The parameters $\omega, \alpha_i, \gamma_i$ are not restricted to be nonnegative.

$$\ln(\sigma_t^2) = \omega + \sum_{i=1}^p \alpha_i \left[\left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \theta_i \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right] + \sum_{j=1}^q \gamma_j \ln(\sigma_{t-1}^2) + \delta_1 DDI + \delta_2 DIR \quad (12)$$

$$\ln(\sigma_t^2) = \omega + \alpha_i \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \theta_i \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \gamma_j \ln(\sigma_{t-1}^2) + \delta_1 DDI + \delta_2 DIR \quad (13)$$

4. EMPIRICAL RESULTS

4.1 Descriptive Statistics

The table below is based on 179 observations (after adjustment) hence providing a more precise estimate of the parameters. The variables present a positive mean for all series with the exchange rate having a mean of (7.106404) and its standard deviation of (0.2203). The dollarization index shows a mean of (0.403384) with a standard deviation of (0.073066). A normal distributed series, skewness is 0 and kurtosis is 3. The skewness and kurtosis data from the statistics clearly indicates departure from normality where DDI (positive skewness) shows that the distribution has a long right tail and DIR and DLNER (negative skewness) has a long left tail. Likewise the Jarque-Bera statistics, also confirms that the null hypothesis of the variables should be rejected and that the variables are not normally distributed.

[\[Table 2\]](#)

4.2 Unit Root Test (Stationary test)

The unit root test was conducted at the level and on the first difference using exogenous regressors with intercept and trend and intercept for each variable. The ADF statistic values and p-values of DI, IR and LNER on table 3, show that these variables are not stationary at the level but at the first difference. This is because the p-values at level are greater than 0.05(5%) while that of the first difference are less than 5%. Therefore we can reject the null hypothesis at the first difference whereby our variables are stationary. [\[Table 3\]](#)

4.3 Test for Heteroscedasticity

In order to test whether the difference in errors from the regression is dependent on the values of the independent variables; hence heteroscedasticity we will use the ARCH-LM test (Lagrange multiplier test) to test for autoregressive conditional heteroscedasticity (ARCH) in the residuals (Engle 1982). The results of the ARCH-LM test on table 4 for heteroscedasticity indicates the presence of ARCH effect in the conditional variance at lag 1 hence we can reject the null hypothesis. The residual graph [\[Figure 5\]](#)

shows the presence of clustering volatility; periods of high volatility are followed by periods of high volatility and periods of low volatility are followed by periods of low volatility. [\[Table 4\]](#)

4.4 Granger causality test

Using the “Granger causality test” we will examine the predictive causality of the data and there after we apply the GARCH models determine how dollarization can influence exchange rate movements. (Barnett et al., 2009) Granger causality test will help us to identify the causal interactions between dollarization and exchange rate. According to the results (table 5) the probability is less than 5% hence we can reject the Null hypothesis therefore suggesting that dollarization index Granger causes the exchange rate. This means that dollarization index contains information that helps predict the fluctuation of exchange rate in Tanzania. The results also suggest that we cannot reject the null hypothesis that exchange rate does not Granger cause dollarization of which we do not have statistical evidence to support that. [\[Table 5\]](#)

4.5 Estimation results for GARCH and EGARCH model

The estimation models selected are GARCH (1,1) and EGARCH (1,1) models. [Table 6](#) below shows the parameter estimation results for GARCH (1,1) and EGARCH (1,1) with the normal, student's t and GED distributions. The estimation results of the models with the conditional distributions including Q-statistics of lag 10 of the standardized and squared standardized residuals, the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC), the Durbin-Watson statistics and their respective p-values in parentheses. The Q-statistics with 10 lags for testing residual serial correlation cannot reject the null hypothesis of no autocorrelation for residuals and squared residuals implying that the models can explain the data well.

Under the normal distribution and GED, the sum of the GARCH parameters ($\alpha_i + \gamma_j$) is less than one for both the GARCH (1,1) model and EGARCH(1,1) model, implying that the shocks in volatility are limited and stationary, while that of student's t is greater than 1 for all models implying that the volatility model is strictly stationary.

The leverage effect term θ for the EGARCH (1,1) is statistically significant and negative indicating the existence of asymmetric and leverage effect in exchange rate volatility, or that the conditional variance has a significant effect on the exchange rate volatility. This indicates that bad news creates speculative bubbles and growth of uncertainties (currency depreciation), particularly when the

socioeconomic and political circumstances are very unpredictable and residents prefer foreign currency over the Tanzania Shilling.

In the case of dollarization with the coefficient δ_1 , the estimates are positive and significant for both GARCH and EGARCH models under student's t and GED distribution while it is negative under normal distribution for both models. If we consider the sample, given the fact that the variable series exhibited some excess kurtosis, it can be predicted that fatter-tailed distributions, such as the Student-t or GED, should generate better results than a simple normal distribution. Therefore the coefficient of dollarization δ_1 is both positive and significant under student's t distribution (0.009304) and GED (0.000083) for the model GARCH (1,1) suggesting that an increase in dollarization leads to an increase in the volatility of the exchange rate. The coefficient of dollarization under the EGARCH model is positive under student's t distribution (15.2187) and GED (3.1403). The results are consistent with the arguments that dollarization can cause instabilities in a flexible exchange rate economy (Akçay et al., 1997). The interest rate (deposit rate) estimates represented by the coefficient δ_2 is negative for both GARCH and EGARCH model under GED and also negative for EGARCH model under student's t but positive under the normal distribution for both models. Other variables in the variance equations are statistically significant throughout. The parameter α_i represents the size effect of the shock on volatility or conditional variance. The value is positive for both GARCH and EGARCH models under normal, student's t and GED distributions. The parameter (γ_j) represents the asymmetric effect of positive and negative shock on exchange rate volatility. The negative signs in γ_j throughout implies that negative shock has a larger impact on the exchange rate volatility than an equal and positive shock; bad news effect volatility more than good news.

5. CONCLUSION AND RECOMMENDATIONS

The most notable phenomenon in the financial sector in Tanzania is the increased use of foreign currency for transactional purposes and also as a way of storing wealth. This paper has explored the impact of dollarization on exchange rate volatility. This paper contributes to the existing literature of exchange rate volatility using the volatility models GARCH and EGARCH with normal distribution, student's t distribution and Generalized Error Distribution for modeling the Tanzanian shilling/US dollar fluctuations in relation to dollarization. According to the measure implemented in our study for evaluating exchange rate fluctuations, the EGARCH model leverage effect θ is positive and statistically significant thus indicating the presence of leverage effect. Moreover, it has been found that the EGARCH (1,1) model presents the smallest AIC and SIC values under student's t distribution, clearly suggesting that EGARCH model coupled with student's t distribution performs very well and is suitable for the data set. Therefore the results present dollarization as an effect to currency fluctuations.

These empirical findings suggest that unofficial dollarization may not be suitable for Tanzania due to the depreciation of the country's currency. However de-dollarization is a lesser option as it can result in various costs to the country and its economy. Evidence from countries like Cambodia and Israel suggest that in highly dollarized countries the reversal process can be costly and unpleasant. Therefore the country should consider implementing strict policies to mitigate financial dollarization. Policies could encourage banks to extend foreign exchange denominated loans mostly to the tradable sector. In the non-tradable sector, banks could be asked to require foreign currency borrowers to actively hedge their loans against exchange rate risk (for example) by buying forward. Since commercial banks also play a vital role in dollarization as residents can hold foreign currency deposits, they should implement a more rigid set of collateral requirements on foreign currency denominated loans to their non-exporting borrowers. Dollarization is at its moderate stage in the economy but with the growth of technology, Tanzania is expected to grow in International business, hence purchase of goods and service will be conducted in US dollars. It is therefore important that policy makers take this into consideration and implement policy measures that could help to stabilize the situation. One of the most direct interventions is to restrict the domestic currency for domestic transactions.

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7. APPENDICES

7.1 Figures and Charts

Figure (1): Exchange rate Fluctuations

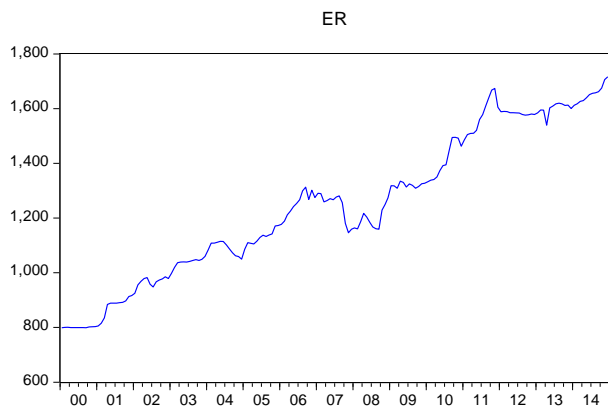


Figure (2): Interest rate

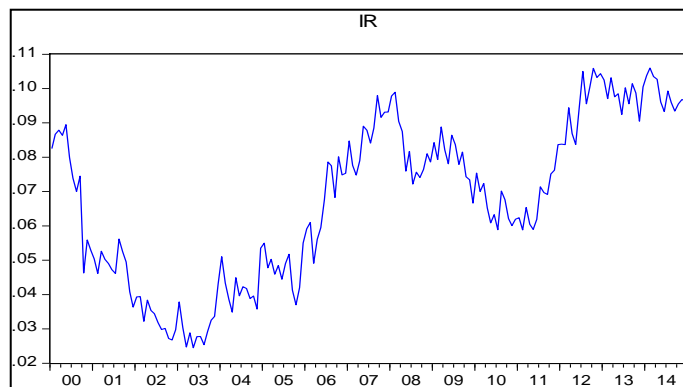


Figure (3): Dollarization Index

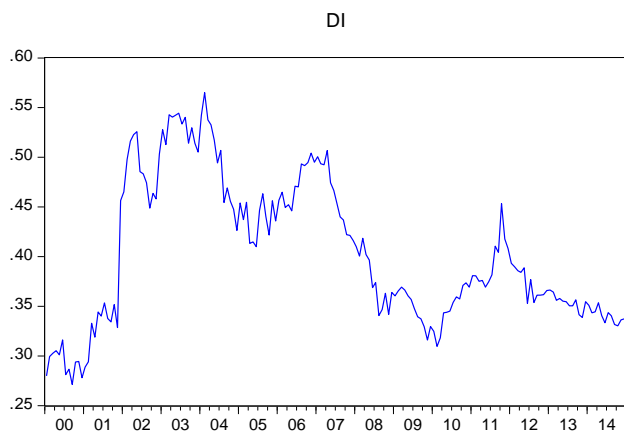


Figure: (4) Foreign currency deposits to Broad money

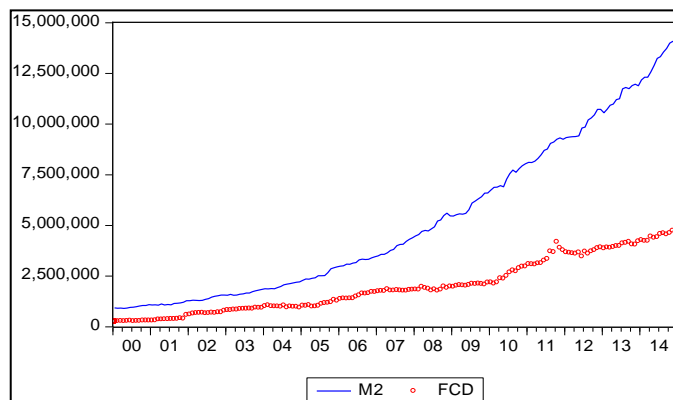
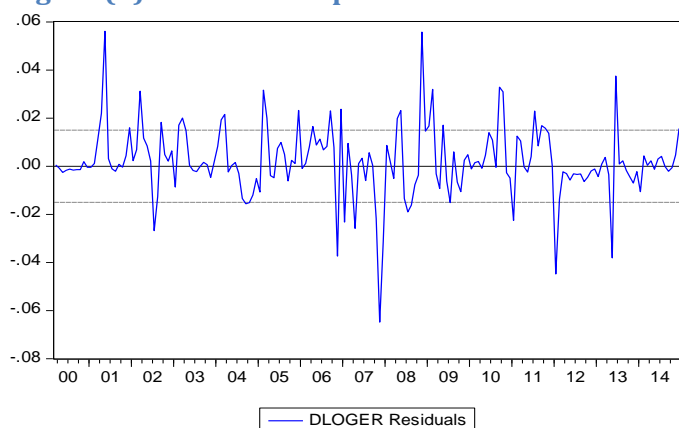


Figure (5): Residual Graph



7.2 Tables

Table(1): VAR Lag Order Selection Criteria

Sample: 2000M01 2014M12

Lag(AR)	SIC
0	-10.88849
1	-17.92863*
2	-17.91875
3	-17.69787
4	-17.49497
5	-17.28016
6	-17.08628
7	-16.88603
8	-16.7049
9	-16.47184
10	-16.26091

* indicates lag order selected by the criterion

Table 2: Descriptive statistics for Main Variables

Variables	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
DI	0.40338	0.56503	0.27123	0.07306	0.36451	2.02257	11.15127
DDI	0.00032	0.12779	-0.05256	0.01920	1.61296	13.03972	829.3851
LNER	7.10640	7.44778	6.68323	0.22030	-0.27648	2.09431	8.44532
DLNER	7.10449	7.44218	6.68323	0.21942	-0.27646	2.09683	8.36396
IR	0.06775	0.10597	0.02451	0.02348	-0.15734	1.80625	11.43049
DIR	0.06759	0.10597	0.02451	0.02345	-0.14860	1.80968	11.22612

Note: DI is dollarization Index, LNER is the log of exchange rate, and IR is Interest rate. DLNER, DDI, DIR represents the first difference of respective variables.

Table 3: Unit root test, Augmented Dickey-Fuller Test (Lag Length: 1 (Fixed - based on SIC, maxlag=13) and Phillips-Perron Test (Bandwidth: 2 (Newey-West automatic) using Bartlett kernel)

Variables	Unit root test					
	With intercept only			With trend and Intercept		
	DI	IR	LNER	DI	IR	LNER
ADF						
Levels	-1.6675	-1.2037	-1.1720	-2.2649	-3.1423	-2.7356
p-value	0.4460	0.6726	0.6862	0.4504	0.0999	0.2237
1st difference	-8.4180	-11.6208	-8.5010	-8.5013	-11.7549	-8.5118
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PP						
Levels	-2.0389	-1.2624	-1.1543	-2.5295	-3.0853	-2.3553
1st difference	-16.2170	-17.1763	-10.3043	-16.3547	-17.0632	-10.2349

Table 4: Test for Heteroscedasticity

Lag Length: 1 (Fixed - based on SIC)

Heteroscedasticity Test: ARCH

F-statistic	2706.3440	Prob. F(2,174)	0.0000
Obs*R-squared	167.1311	Prob. Chi-Square(2)	0.0000

Table 5: Granger Causality Test

Sample: 2000M01 2014M12

Lags: 1

<u>Null Hypothesis:</u>	<u>Obs</u>	<u>F-Statistic</u>	<u>Prob.</u>
DDI does not Granger Cause DLNER	178*	8.5683	0.0039
DLNER does not Granger Cause DDI		2.6370	0.1062

*observations after adjustments

Table 6: GARCH and EGARCH estimates under normal, student t and GED conditions.

	GARCH (1,1)			GARCH (1,1)			EGARCH (1,1)		
Coefficients	Normal	student t	GED	Normal	student t	GED	Normal	student t	GED
Mean Equation									
Constant	0.0226	-0.0187	0.0470	0.0143	-0.0148	0.0448	0.0465	-0.0101	0.0457
DLOGER(-1)	0.9974	1.0030	0.9938	0.9986	1.0024	0.9941	0.9940	1.0018	0.9940
Variance Equation									
	0.0002	0.0007	0.0001	0.0000	0.0015	0.0001	-	-0.7290	-8.6301
	0.4214	18.5062	0.8697	0.3740	40.4777	0.8344	0.5496	49.7372	0.8218
	-0.1135	-0.0142	-0.0330	-0.1033	-0.0149	-0.0351	-0.1307	0.6085	0.0335
	0.3079	18.4920	0.8367	0.2708	40.4628	0.7993	0.4189	50.3457	0.8553
							-0.1050	-0.8826	-0.1045
				-0.0001	0.0093	0.0001	-0.1042	15.2187	3.1403
				0.0020	0.0007	-0.0002	5.9501	-1.7957	-2.3394
GED Parameter			0.7888 [0.0000]			0.7886 [0.0000]			0.8074 [0.0000]
t-distribution		2.0531 [0.0000]			2.0231 [0.0000]			2.0002 [0.0000]	
Q(10)	14.5060 [0.151]	8.2530 [0.604]	12.2390 [0.269]	17.5250 [0.064]	7.7512 [0.653]	11.9410 [0.289]	17.0010 [0.074]	9.7387 [0.464]	13.7600 [0.184]
Q2(10)	2.4823 [0.991]	3.2342 [0.975]	3.592 [0.964]	3.5628 [0.965]	2.9931 [0.982]	3.3974 [0.970]	3.3163 [0.973]	4.3839 [0.928]	3.1323 [0.978]
DW	1.5137	1.4740	1.4955	1.5129	1.4777	1.4973	1.5124	1.4821	1.4964
AIC	-5.6333	-5.9445	-5.8881	-5.6285	-5.9248	-5.8688	-5.6217	-5.9662	-5.8688
SIC	-5.5440	-5.8373	-5.7808	-5.5033	-5.7818	-5.7258	-5.4787	-5.8053	-5.7079

Note: Q(k) and Q2(k) are Ljung-Box Q-statistics with k lags for the standardized residuals and squared residuals respectively, and p-values in parenthesis. AIC represents Akaike Information Criterion, SIC is Schwarz Information Criterion and DW is Durbin-Watson test. The bold figures represent the smallest SIC and AIC values respectively.

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The Editor