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DOES DOLLARIZATION ALLEVIATE OR AGGRAVATE EXCHANGE RATE VOLATILITY?

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Relying on hard currency or *dollarizing* an economy has been a common practice of many developing countries taking the form of dollarizing bank deposits and loans, settling transactions in dollars and the indexation of wages and prices in dollars. The relationship between dollarization and exchange rate volatility is both theoretically and empirically unresolved. While the effect of such practices has been the focus of numerous investigations, such studies have concentrated on the Latin American and Asian economies. This paper contributes to the limited research on the African economies by specifically investigating the consequences of dollarization on Eritrean exchange rate volatility. Using quarterly official and black market exchange rate data for the study period 1996-2008, E-GARCH analysis suggests that dollarization has a positive impact on real exchange rate volatility.

Keywords: Dollarization, Exchange Rate Volatility, Eritrea, Official and Black Market
JEL classification: F3, O2, O5

1. INTRODUCTION

The dollarization of the developing countries has been an inspiring field of research for many scholars. Despite a number of studies that address the measurement and consequences of dollarization, this literature concentrates on the Latin American and Asian economies with very limited focus on African economies. In this paper, we investigate whether dollarization alleviates or aggravates exchange rate volatility in the case of Eritrea. The existing literature suggests that the impact of dollarization can depend on the form of dollarization that exists in a given economy. For example, Akofio-Sowah (2009), Savvides (1996), Schnabl, (2007) and Barrell *et al*. (2009) among

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others show that if dollarization is full, then dollarization minimises exchange rate volatility. Similarly, Fielding and Shields (2003) argue that full monetary union leads to lower real exchange rate volatility than is the case under a fixed exchange rate system. However, if dollarization takes a partial form, then the evidence is less clear-cut. The theoretical work of Girton and Roper (1981), Akcay *et al*. (1997) and Corrado (2008) demonstrate that exchange rate instability increases with the increase of the degree of currency substitution. Empirical studies by Calvo and Vegh (1992, 1996), Yinusa (2008) and Akcay *et al*. (1997) suggest that an increase in dollarization increases the exchange rate volatility. In contrast to these studies, Devereux and Lane (2003) find that financial dollarization in the form of acquiring dollar loans alleviates exchange rate volatility.

In addition to an African focus, our contribution to the literature is further enhanced through the construction and utilisation of a new hard currency index based on a holistic approach towards its measurement. This approach suits the nature of the Eritrean economy and addresses the shortcomings of alternative measures of dollarization adopted by earlier studies. In further contrast to the existing literature, we analyse both the official and black market exchange rate in both nominal and real form.

The paper is organized as follows. In the following section, we briefly review the relevant literature. The third section discusses the data and methodology. Quarterly time series data for Eritrea are employed for the study period 1996Q1-2008Q4. Estimation is based on extending the Exponential Generalised Autoregressive Conditionally Heteroscedasticity (E-GARCH) model originally proposed by Nelson (1991). The fourth section offers a discussion of the econometric findings. We find that dollarization has a positive impact on exchange rate volatility. The final section offers a summary and conclusion.

2. LITERATURE REVIEW

Dollarization, which refers to the use of US dollars or any other foreign currency within the domestic economy, has become a contemporary economic feature of many countries from the developing world. Some of these countries are fully dollarized while others are partially dollarized. Fully dollarized cases include Ecuador, El Salvador, Panama, Micronesia and the Marshall Islands in which U.S. dollar is legal tender; the Cook Islands, which uses the New Zealand dollar; Kiribati and Nauru which use the Australian dollar; Montenegro, Monaco, Kosovo, San Mario and Vatican City which use the Euro and so on. Partially dollarized economies include Angola, Malawi, Nigeria, Bolivia, Uruguay, Peru, Cambodia, Vietnam, Armenia and Turkey among others.

The decision of these countries to either fully or partially dollarize has been due to political or economic considerations such as high inflation, currency instability and strong trade ties with a particular country that generates the demand for another currency. Whether dollarization takes a full or partial form, it has been argued that a significant effect is exerted on exchange rate volatility. This is a major concern because exchange

rate volatility has many undesirable economic and financial effects such as discouraging trade flows, increasing equity market volatility, decreasing growth and discouraging investment (see, for example, Kazunobu and Fukunari, 2009; Bahmani-Oskooee and Paysteh, 1993; Bahmani-Oskooee, 1996; Bahmani-Oskooee *et al*., 2012; Ekanayake and Tsujii, 1999; Kyung-Chun, 2008; and Gunther, 2009). While studies such as Hviding *et al*. (2004), Benita and Lauterbach (2007), Canales-Kriljenko and Habermeier (2004) have identified interest rate, central bank intervention, regulation of the foreign exchange market and decentralization of the dealers' market as key factors affecting exchange rate volatility, few studies have considered the role of dollarization itself.

While those studies that investigate the impact of full dollarization find less volatility of the exchange rate as a consequence, studies that examine partial dollarization provide contradictory results. Among those that consider the impact of full dollarization, the studies by Akofio-Sowah (2009), Bogetic (2000) as well as Lange and Sauer (2005), for example, highlight a reduction in the exchange rate volatility of Latin American countries. The studies by Schnabl (2007), Barrell *et al*. (2009), Bartram and Karolyi (2006), and Clark *et al*. (2004) indicate a decline in exchange rate volatility in the Euro zone area. Similarly, Savvides (1996) shows that exchange rate volatility is lower in the Coopération financière en Afrique central (CFA) Franc zone than non-Franc Zone.

In contrast to this, a number of studies on the impact of partial dollarization find an increase in volatility. Girton and Roper (1981) develop a model that shows the impact of currency substitution on exchange rate instability insofar as the greater the degree of currency substitution, the larger the movement of the exchange rate. Corrado (2008) develops a model that also suggests that real dollarization in the presence of financial dollarization causes higher exchange rate movements. Similarly, Akcay *et al*. (1997) develop a theoretical model to show the increase in the instability of exchange rate as a result of currency substitution. They conclude that as the degree of currency substitution increases, there is a greater required change in the exchange rate that will equilibrate the change in the rate of exchange.

Besides their theoretical derivation of a positive impact of dollarization on the exchange rate volatility, using E-GARCH modelling, Akcay *et al*. (1997) empirically finds that volatility increases with an increase in the degree of currency substitution. Likewise, Bahmani-Oskooee and Domac (2003) and Yinusa (2008) provide similar findings for the Turkish and Nigerian exchange rates respectively. The studies by Calvo and Vegh (1992, 1996) have also show a positive correlation between exchange rate volatility and currency substitution. However, studies such as Honig (2009), Berkmen and Cavallo (2010) and Berg and Borensztein (2000) highlight a different outcome. Their message is that even if dollarization causes exchange rate volatility, it encourages policy makers to engage in different techniques of exchange rate stabilization. According to Calvo and Reinhart (2002) terminology, this is due to the presence of the so called "fear of floating". The impact of partial dollarization on volatility is mitigated as the authorities engage in automatic exchange rate stabilization.

If countries aim to stabilize their nominal exchange rate or adopt a fixed exchange

rate regime as in the studies above, will it be possible to see less exchange rate volatility in their economy even in the presence of dollarization? Do the efforts to stabilize the exchange rate work while there is partial dollarization? The answer to these questions may rest on whether the economy is free of black market activity in the foreign exchange market and whether the domestic money supply is flexible enough to cope with any disturbances. Therefore, the findings of Berkmen and Cavallo (2010), Berg and Borensztein (2000) and Honig (2009) may only be valid in countries for which there is very little or no black market activities or parallel markets. In countries where there is an active black market for foreign exchange, one would expect to observe exchange rate volatility even if the authorities have stabilized the official exchange rate.

The early work by Girton and Roper (1981) shows that exchange market intervention may not help stabilize exchange rate volatility under partial dollarization even if there is no black market system in the economy. Similarly, Corrado (2008) argues that real dollarization along with financial dollarization makes the achievement of less costly stabilization programs very difficult. In a different approach, Devereux and Lane (2003) find that external financial linkages with the creditor countries in the form of bank loans lowers bilateral exchange rate volatility in developing countries. Despite the dissimilarity in the findings of these studies, it is quite logical to assume that partial dollarization would aggravate exchange rate volatility. This assumption is based on the fact that the existence of partial dollarization indicates the existence of currency and/or asset substitution in the economy. If agents are swapping foreign and domestic currencies, the value of foreign exchange is likely to respond to fluctuations in currency demand. Moreover, if demand plays greater role than supply in the determination of the exchange rate, it is likely that the equilibrium exchange rate will not be observed for a lengthy period of time. If an economy is fully dollarized, however, the foreign currency is adopted as legal tender. The volatility of the foreign currency itself becomes the volatility of the domestic currency. Many developing countries, however, fix their currencies against a hard currency which makes the volatility of the hard currency minimal.

3. DATA AND METHODOLOGY

Eritrea was under the control of Ethiopia for a long period of time and got its official independence in 1993**.** As an independent nation, therefore, Eritrea has a relatively short economic history. This restricts our viable study period to 1996Q1-2008Q4. The standard measure of dollarization which is commonly used by IMF and others is the ratio of foreign currency deposits to broad money in the economy.[1] This method,

[1] See Agenor and Khan (1996), Yinusa (2008), Clements and Schwartz (1993), Viseth (2001), Komarek and Martin (2001) and Akcay *et al.* (1997).

however, only captures *financial dollarization* thereby neglecting other forms of dollarization that can exist. Furthermore, although aimed at capturing financial dollarization, this measure in fact only considers onshore dollar deposits and fails to incorporate offshore dollar deposits. Other studies have used the ratio of foreign currency deposits to total bank deposits.[2] Another approach develops the original sin and composite indices in measuring partial dollarization.[3] Despite the differences in their methods of measurement, these approaches have only focused on some limited aspect of dollarization. While the sin index is useful only in capturing the liability dollarization, the composite index puts emphasis on dollar loans issued to the government without including the dollar loans issued to the private sector. In order to address this limitation, we develop and employ an index that incorporates the overall dollarization of the Eritrean economy.[4] This approach has the advantage of incorporating as many aspects of dollarization as possible.

We first consider the foreign exchange reserves in the Eritrean economy used to finance the import of goods from abroad and service the external debt. Let

$$M_t^E = \alpha_t FR_t^T , \tag{1}$$

where M_t^E is import expenditure, FR_t^T is total foreign exchange reserves, and $0 \le \alpha_t \le 1$ is the proportion of total foreign exchange reserves used for financing the expenditure for imported goods. M_t^E is used to express import expenditure if there is no other source of finance available such as dollars from the black market. The remaining proportion of FR_t^T can be used to service debt, DS_t, or carry foreign exchange reserves forward FR_t^R as follows

$$(FR_t^R + DS_t) = (1 - \alpha_t) FR_t^T . \tag{2}$$

Adding Equations (1) and (2) provides

$$M_t^E = FR_t^T - FR_t^R - DS_t . \tag{3}$$

Equation (3) provides a number of scenarios

$$\text{If } FR_t^R = 0 \text{ and } DS_t > 0 \text{, then } M_t^E = FR_t^T - DS_t . \tag{4}$$

[2] See Yeyati (2006), Rennhack and Nozaki (2006) and Nicolo *et al.* (2005).

[3] See Hausmann *et al.* (2001), Hausmann and Panizza (2003) and Reinhart *et al.* (2003).

[4] Detailed discussion on the construction of this index can be found in Mengesha and Holmes (2011).

If FR_t^R and $DS_t > 0$, then $M_t^E = FR_t^T - FR_t^R - DS_t$. (5)

If FR_t^R and $DS_t = 0$, then $M_t^E = FR_t^T$. (6)

Of these three cases, Equations (4) and (6) reflect the Eritrean economy more realistically than Equation (5). With the exception of 1996, Eritrea has been servicing its debt each year since 1995. Therefore, $DS > 0$ each year except 1996 where $DS = 0$. Since there is shortage of hard currency earnings and high demand for foreign currency to finance the importation of goods, information on the foreign exchange reserves of Eritrea indicate that there are no remaining foreign exchange reserves carried forward to the next period.[5]

The next step is for us to identify the amount of hard currency in the Eritrean black market which is also used to finance the import of goods. Unlike countries where imports are formally registered and international payments are done through the banking sector, international payments are not necessarily conducted via the banking sector in the Eritrean economy. Banks hardly sell hard currency to importers due to high demand for hard currency and foreign exchange reserve crisis. As a result, importers obtain the hard currency through their own means via the black market. Therefore, the actual imports of goods (M_t^A) are not only financed by the α_t share of the total foreign exchange reserves as determined above, but also by the hard currency supplied by the black market. The difference between M_t^A and the imports of goods financed by total foreign exchange reserves (M_t^E) can be written as

$$B_t = M_t^A - M_t^E, \tag{7}$$

where B_t denotes the amount of hard currency obtained from the black market to finance import expenditure. Substituting Equation (3) into (7) provides another three scenarios

$$B_t = M_t^A - (FR_t^T - DS_t), \text{ if } FR_t^R = 0 \text{ and } DS_t > 0, \tag{8}$$

[5] It should be noted that export earnings do not explicitly appear in the above equations, This is because export earnings are included in the measurement of foreign exchange reserves. When FR_t^R is zero, then FR_t^T comes from export earnings which will then be used to finance import expenditure. The fundamental cause for this scenario is not only the shortage of foreign exchange reserve in the Eritrean economy, but also the higher demand for hard currency required to finance the import expenditure needed to sustain the economy.

$$B_t = M_t^A - (FR_t^T - FR_t^R - DS_t), \text{ if } FR_t^R \text{ and } DS_t > 0, \quad (9)$$

$$B_t = M_t^A - (FR_t^T), \text{ if } FR_t^R \text{ and } DS_t = 0. \quad (10)$$

As discussed above, Equations (8) and (10) depict the most appropriate cases in determining the amount of hard currency used to finance imported goods through the black market. We now measure the overall Eritrean dollarization. Incorporating the three types of dollarization-claims on foreign commercial banks, external debt and hard currency supplied by the black market- we have the following index

$$HCI_t = \frac{DL_t + B_t + FB_t}{M2_t - DCC_t}, \quad (11)$$

where HCI_t is the hard currency index, DL_t is dollar loans issued by the Eritrean banks, B_t is the amount of hard currency supplied by the black market, FB_t is foreign borrowing, $M2_t$ is the money supply and DCC_t is domestic currency in circulation. DCC_t is subtracted from $M2_t$ for the purpose of not under estimating the weight of hard currency in the financial system. It should be noted that this paper is not only interested in incorporating the holdings of dollars in the black market but also in incorporating the overall forms of dollarization in the Eritrean economy. As such the index includes the financial dollarization, underground dollarization which is measured by the holdings of the hard currency in the black market and the liability dollarization that exist in the economy. This approach is justified on the grounds that the measurement not only traces the amount of hard currency supplied by the black market to finance import expenditure, but also it addresses all types of dollarization that prevail in the Eritrean economy.[6]

The data sources used in the construction of the index are summarized in the Appendix**.** Using quarterly data on all these variables, Figure 1 plots the *HCI* series.

[6] With regard to this index in relation to the informal holdings of dollars for savings or conducting transactions domestically, it is important to bear in mind the purpose of holding the hard currency. In Eritrea, the means of payment for domestic transactions are required to be settled through the local currency by regulation. The hard currencies that flow into the hands of the individuals (households) through informal means have to be exchanged for local currency to be able to purchase the domestically traded products. The holding of the hard currencies is due to their strong purchasing power when they are exchanged for the local currency. It can, therefore, be seen that the primary motive of the holding of the hard currency by consumers is not for saving or conducting transactions domestically.

Figure 1. The Hard Currency Index

While there has been a general upward trend in the *HCI* over the study period, there was a sharp fall in 1997. This fall was driven by the lower dollar loans issued by the banks. The *HCI* has continued to rise especially from 2002 onwards. This could be an effect of the second war with Ethiopia. Prior to these events, goods were mainly imported from Ethiopia and transactions were settled in Birr which was former local currency unit for both countries. After the introduction of the new currency and the second war, however, imports needed to be sourced from other countries as Eritrea lost its access to the Ethiopian market. Importing from other countries in turn enhanced the demand for hard currency as the transactions were required to be settled in hard currency. In addition to this, the Eritrean economy lost an equivalent amount of 43.02 million U.S. dollars from export earnings to Ethiopia. Moreover, the growth of Eritrean GDP declined from an annual average of 10.8 percent prior to the introduction of the new currency to 0.2 percent over the period of 1998 to 2007. The loss in export earnings coupled with the fall in GDP growth made the economy more reliant on foreign borrowing and imported goods. The rise in the demand for imported goods and the need to settle transaction in hard currency for imported goods therefore increased the reliance on hard currency as reflected in the *HCI*.

In measuring the exchange rate, both official and black market data are used. Eritrea not only has an official market exchange rate system, but also has a parallel market. This was a legal market prior to 1997, but thereafter became a black market for foreign exchange due to restrictions. The exchange rate of the black market is included in the

analysis since the official exchange rate has been fixed since 2003 (apart from a hike in 2005). The returns on both forms of exchange rates are plotted in Figure 2. The data for the official nominal exchange rate (*RETURNOM*) are obtained from the Balance of Payments of Eritrea IMF file number 643. The data for the nominal black market exchange rate (*RETURNBM*), however, is obtained from the unpublished records of the participants in the Eritrean exchange market. For the purpose of computing real official and black market exchange rates, Eritrean and U.S consumer price index data are obtained from International Financial Statistics, while part of the Eritrean CPI data are also obtained from the IMF World Economic outlook. Since quarterly Eritrean CPI data from 2003 onwards are not available, these later values are interpolated using an autoregressive and disaggregating techniques. Annual data on the import of goods and services as well as debt service are collected from World Development Indicators of the World Bank. The INTER procedure is used in disaggregating these data.[7]

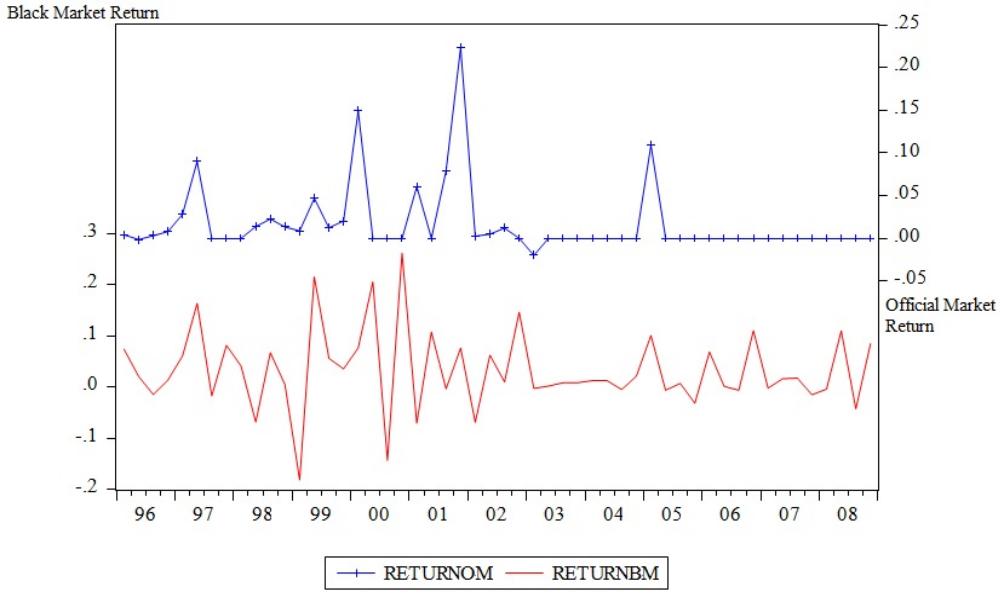

Figure 2. Official versus Black Market Returns

[7] According to the study of Chan (1993), some of the disaggregating methods are the NAÏVE procedure, the INTER procedure, the LS procedure, the BFL-LD procedure, the BFL-SD procedure, the WS procedure. Of these procedures, the INTER procedure and the WS procedure performed well relative to others in his study of the comparison of these procedures against the actual data.

The most commonly used measurements of exchange rate volatility are based on the unconditional variance and conditional variance σ_t^2 derived from the ARCH family of models.[8] The early work by Rana (1981) on exchange rate volatility in eight Asian countries shows that measuring volatility using the unconditional standard deviation is both inconsistent and misleading if the underlying distribution of exchange rate returns is non-normal. In our study, the distribution of the exchange rates of both markets was found to be leptokurtic**,** a distribution with positive excess kurtosis. We measure volatility using an E-GARCH-in-mean (E-GARCH-M) model. This model has key benefits over the standard GARCH (1,1) model in that log σ_t^2 is used in the specification of the variance equation instead of σ_t^2 which ensures that σ_t^2 is positive. The E-GARCH-M model can also capture asymmetric effects of positive and negative shocks on exchange rate volatility. The conditional variance of both the official and black market real exchange rates are demonstrated in Figure 3 below.

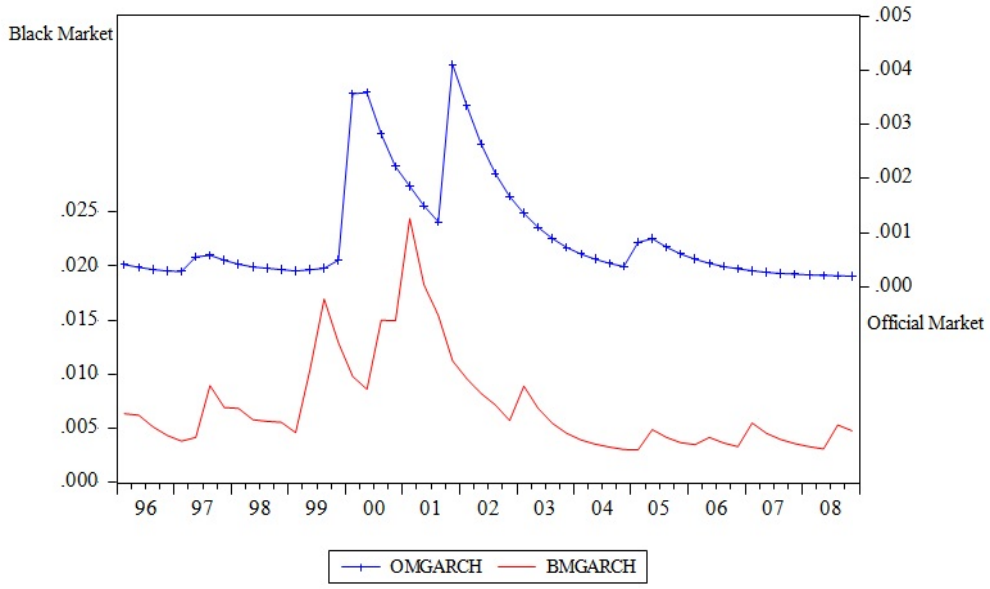

Figure 3. Conditional Variance of Official versus Black Market Exchange Rates

As can be seen from the figure, relative to the conditional variance of the black market real exchange rate (*BMGARCH*), the conditional variance of the official real

[8] See Akcay *et al*. (1997), Brodsky (1984), Dell (1999), and Kenen and Rodrick (1986).

exchange rate (*OMGARCH*) is generally more stable apart from a few ups and downs. The conditional variance of the black market exchange rate, on the other hand, was high during 1997-2001, but became less so thereafter. This might be attributable to competition from the official exchange rate which was flexible during those periods.

We follow the approach advocated by Akcay *et al*. (1997) by augmenting an E-GARCH-M model through the inclusion of a dollarization variable in the conditional variance equation.

$$\varepsilon_t = \alpha + \Phi \ln \sigma_t^2 + u_t, \tag{12}$$

$$\ln \sigma_t^2 = \omega + \delta h_t + \varphi \frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} + \gamma \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \psi \ln \sigma_{t-1}^2, \tag{13}$$

where ε_t is the return on exchange rate (*e*) calculated as $\ln \frac{e_t}{e_{t-1}}$ or $\ln e_t - \ln e_{t-1}$. $\ln \sigma_t^2$ is the natural logarithm of the conditional variance, u_t is a random error term, h_t is a variable for the hard currency index used as a measurement of dollarization. The structure of the error term is assumed to have a generalized error distribution; α, Φ, ω, δ, φ, γ, ψ are the parameters to be estimated where α captures the conditional mean, γ captures the asymmetric effects of the positive and negative shocks on exchange rate volatility. The parameter φ determines the size effect of the shock on volatility. The impact of the lagged conditional variance is captured by ψ. δ determines the effect of dollarization on exchange rate volatility. If δ is positive and statistically significant, it suggests that an increase in dollarization increases exchange rate volatility. The effect of the conditional variance on exchange rate returns is determined by Φ.

4. RESULTS

Table 1 reports that the mean return and standard deviation of the real official exchange rate (*REALRETURNOM*) is small relative to the nominal and real black market rates (*RETURNBM* and *REALRETURNBM*). The skewness and kurtosis along with the normality tests based on Jarque-Bera statistics point towards non-normality for all series. ADF testing suggests that non-stationarity can be rejected at the 10% level of significance or better throughout. Table 2 reports the findings from Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) unit root tests and Kwiatkowski, Phillip, Schmidt and Shin (KPSS) stationarity tests which indicate that the hard currency index is first difference stationary.

Table 1. Statistical and Stationarity Results of the Returns

Series	Mean	Std. Dev.	Skewness	Kurtosis	Normality	ADF Statistic
RETURNBM	0.0328	0.0799	0.3751	4.366	5.2637	-3.9996
REALRETURNOM	0.0045	0.07331	3.4906	18.090	599.01	-6.8370
REALRETURNBM	0.0202	0.1012	1.5526	8.875	95.690	-2.6231

Table 2. Unit Root and Stationarity Tests on the Hard Currency Index

Tests	Levels		First Differences	
	Without Trend	With Trend	Without Trend	With Trend
ADF (AIC)	-1.206	-3.300	-7.487	-7.427
	(0.665)	(0.078)	(0.000)	(0.000)
PP	-1.206	-3.300	-7.488	-7.428
	(0.665)	(0.078)	(0.000)	(0.000)
KPSS	0.803	0.114	0.127	0.110

Notes: The values in parentheses are p-values. The results from ADF testing are the same irrespective of SIC or AIC lag length criteria.

A seemingly volatile movement of the real exchange rate may be due to the nonlinear adjustment of the real exchange rate (see, for example, Taylor *et al*., 2001, and others). One may think in terms of a central bank that is more likely to intervene in the foreign exchange market when there is a large deviation of the exchange rate, which causes the nonlinearity. Also, a key factor could be related to transactions costs in arbitrage that lead to thresholds. If the Eritrean currency is characterised as nonlinear, then the volatility measure used in this study is not irrelevant. We therefore consider whether or not there is evidence of non-linearities in the three real exchange rate series. Many tests have been proposed in the literature for detecting non-linearity. Instead of using a single statistical test, four different tests are considered for the purposes of this paper: McLeod and Li (1983) for an ARCH alternative, Engle (1982) for GARCH, Brock *et al*. (1996) (BDS hereafter) for a general linearity test, and Tsay (1986) for Threshold effects. All these tests share the principle that once any (linear or non-linear) structure is removed from the data, any remaining structure should be due to a (unknown) non-linear data generating mechanism. All the procedures embody the null hypothesis that the series under consideration is an *i.i.d.* process.

Table 3. Tests for Non-linearity

	REALRETURNBM	REALRETURNOM	RETURNBM
MCLEOD-LI TEST:			
USING UP TO LAG 1	0.783	0.735	0.099
USING UP TO LAG 8	0.023	0.999	0.046
USING UP TO LAG 16	0.903	0.754	0.090
ENGLE TEST:			
USING UP TO LAG 1	0.682	0.745	0.002
USING UP TO LAG 8	0.000	0.815	0.235
USING UP TO LAG 16	0.020	0.015	0.100
TSAY NL TEST:	0.109	0.820	0.001
BDS TEST:			
Dimension *m*			
2	0.000	0.010	0.000
3	0.015	0.016	0.004
4	0.062	0.050	0.036

Notes: The BDS test statistic tests the null hypothesis that a series is *i.i.d.* against the alternative of realisation from an unspecified non-linear process. *m* is the embedding dimension. Given that the choice of *m* is crucial for the power of the test, we report the results for different plausible values of *m* as suggested by Brock *et al*. (1996). Only *p*-values are reported.

Table 3 reports that the Engle test rejects the randomness hypothesis (all *p*-values <0.1) implying that GARCH effects are present, particularly when we consider higher lag structures. The McLeod-Li tests point towards the presence of ARCH-type structures in the cases of *REALRETURNBM* and *RETURNBM* and the Tsay tests point towards threshold effects in the case of *RETURNBM*. The BDS test statistic provides strong evidence that important nonlinearities exist in all series. Therefore, we could argue that the linear representations cannot capture the dynamics of the real exchange rate series.

These results point to the presence of nonlinearities in the behaviour of the three Eritrean real exchange rates. It is important to reflect on the implications of this finding. This supports the case for employing a nonlinear econometric framework such as a GARCH modelling approach. In terms of other implications, it is helpful to consider the implications for nonlinear real exchange rate adjustment discussed by Taylor *et al*. (2001) and others. Moreover, there may be significant deviations from the law of one price due to international transactions costs between spatially separated markets. In these models, the exchange rate becomes increasingly mean-reverting with the size of the deviation from the equilibrium level. A key factor here is nonlinear real exchange rate adjustment that arises from transactions costs in international arbitrage which give rise to thresholds. These thresholds may not only reflect shipping costs and trade barriers, but also sunk costs of international arbitrage and the resulting tendency for traders to wait for sufficiently large arbitrage opportunities to open up before entering the market.

This type of "iceberg model" can be extended to allow for fixed as well as proportional costs of arbitrage. This can result in a two-threshold model where the real exchange rate is reset by arbitrage to an upper or lower inner threshold where, say, arbitrage will be heavy once it is profitable enough to outweigh the initial fixed cost but will stop short of returning the real rate to the purchasing power parity or PPP level because of the proportional arbitrage costs.

Table 4 reports the estimated E-GARCH-M (1,1) model. As discussed previously, the hard currency index is incorporated into the conditional variance equation explaining the official and black market real and nominal exchange rates. The results of official nominal exchange rate are not reported as this has been fixed through much of the study period. The results show that there is volatility persistence in both the nominal and real black market exchange rates. The variance equation estimates point to the possibility that the real official exchange rate is non-stationary in variance. This may be a result of official nominal exchange rate being prone to intervention and distortion during the study period.

Table 4. E-GARCH -M (1,1) under Both Markets and Both Forms

Parameters	Nominal Exchange Rate	Real Exchange Rate	
	Black Market	Official Market	Black Market
α	0.412	-0.001	1.498
	(10.304)	(-104.26)	(2.773)
Φ	0.074	5.365	0.318
	(7.371)	(12.410)	(3.870)
ω	-7.058	-4.075	-6.455
	(-24.500)	(-190.28)	(-10.28)
δ	2.141	5.484	0.628
	(6.021)	(5.541)	(3.134)
φ	0.478	-3.206	0.183
	(5.768)	(-91.964)	(2.054)
γ	-0.440	-1.047	-0.216
	(-5.944)	(-5.067)	(-2.047)
ψ	-0.282	-0.038	-0.355
	(-8.664)	(-14.305)	(-157.2)

Note: The values in the parentheses are t-ratios.

We first focus on the estimates for the mean equations. These results indicate that the conditional variance has a positive and significant effect on the exchange rate returns variable regardless of what form of exchange rate is used with an estimate for Φ of 0.074 for the black market nominal exchange rate. The corresponding estimates using

real exchange rate data are 5.365 and 0.318. These results indicate that the more volatile the exchange rate, the weaker the value of the currency. This finding is consistent with Akcay *et al*. (1997). In the case of the variance equation, the estimates for δ are both positive and statistically significant in all cases. This result suggests that an increased reliance on hard currency leads to increased volatility in the black market foreign exchange market. The same conclusion can also be drawn with respect to real official exchange rate. This finding is in line with the empirical findings of the majority of the literature on the impact of partial dollarization on exchange rate volatility that we have reviewed so far. Other characteristics of the variance equations to note concern the estimates φ and γ which respectively capture the size and sign effect of shocks on conditional variance. These estimates are significant throughout. The negative signs on γ captures an asymmetric effect whereby negative news has a larger impact on the exchange rate volatility than an equal and opposite positive shock.

Given the valuable insights provided by GARCH modelling, it is of interest to compare the persistence of the Eritrean exchange rate variance with that of other dollarized economies. For this, we take a sample of seven other economies that are characterised by varying degrees of partial dollarization. These are Armenia, Bolivia, Cambodia, Egypt, Hong Kong, Singapore and Turkey. For each of these countries, we estimate a GARCH (1,1) model for the real official exchange rate and compute a measure of persistence based on adding the estimated ARCH and GARCH coefficients taken from the variance equations. The findings are reported in Table 5 and indicate that volatility persistence is relatively low in the case of Eritrea. Compared to other dollarized economies, the half-life attached to a news shock is relatively short when we consider the response of volatility.

Table 5. Persistence of Dollarized Real Official Exchange Rates

	ARCH	GARCH	Persistence
Armenia	-0.216	0.800	0.584
Bolivia	0.723	0.359	1.082
Cambodia	0.547	0.351	0.898
Egypt	0.644	0.700	1.344
Eritrea	-0.047	0.575	0.528
Hong Kong	0.066	0.787	0.853
Singapore	0.647	0.206	0.853
Turkey	0.512	0.447	0.959

Note: For each of the above real official exchange rate returns, persistence is measured as the sum of the ARCH and GARCH coefficients obtained from the estimation of a GARCH (1,1) model.

The results here suggest a need for policy intervention in Eritrea. There is evidence that the domestic currency gets weaker with an increase in exchange rate volatility. This can be expected to erode confidence in the domestic currency and create more demand for alternative stronger currency. As a result, this enhances the dollarization process and promotes more dollarization in the economy. This increased partial dollarization in turn sustains the aggravation of exchange rate volatility. In order to control this spiral involving increased volatility, the monetary authorities need to implement policy measures that restore the credibility of the domestic currency. This can require the building of sound economic and financial systems that promote growth and foster the confidence of investors as well as consumers.

5. CONCLUSION

This paper has explored the impact of relying on hard currency, or dollarizing an economy, on exchange rate volatility. Specifically, the paper has investigated whether partial dollarization alleviates or aggravates exchange rate volatility by conducting an investigation based on GARCH modelling. Given the numerous definitions and degrees of dollarization that have been employed in earlier work, an alternative method has been used to estimate the amount of hard currency supplied by the black market thereby capturing underground dollarization.

Other studies have shown that dollarization may alleviate or aggravate exchange rate volatility depending on its form in the economy. Our results show that partial dollarization in Eritrea has both a positive and significant impact on official and black market exchange rate volatility. A number of avenues of future research arise from this study. First, the alternative method employed in measuring dollarization offers potential in future investigations of dollarization in other countries with particular focus on the black market. Second, if the monetary authority is keen to control exchange rate volatility then the causes and drivers of dollarization need to be examined closely. In this respect, appropriate policy design may involve the creation of strong and credible institutions that can underpin confidence in the domestic currency.

APPENDIX

To measure the hard currency index, quarterly data on foreign exchange reserves are obtained from the IMF *International Financial Statistics* (IFS). Due to data limitations, M2 was considered in lieu of a measurement of broad money. However, quarterly data on M2 were also not available for the full study period. Therefore, M2 was calculated as the sum total of M1 and quasi money. Domestic currency in circulation was deducted

from this measure of broad money in order not to understate the weight of dollar loans issued by the banks. Quarterly data on domestic currency in circulation were also obtained from the IFS database.

In computing the dollar loans issued by the banks, quarterly data on total foreign assets, foreign exchange reserves and gold reserves are required as the data for dollar loans were not fully available. The sum total of foreign exchange reserves and gold reserves then were subtracted from total foreign assets to obtain the dollar loans. Quarterly data on total foreign assets, gold reserves and foreign exchange reserves are obtained from Balance of Payments of Eritrea IMF file number 643 as well as from IFS.

The amount of foreign borrowing was obtained by adding total multilateral loans, cross-border loans from BIS reporting banks and cross-border loans from BIS banks to non-banks. Quarterly data on these variables are obtained from the *Joint External Hub*. The data on the import of goods and services as well as debt service are available in the form of annual frequency. These data were collected from *World Development Indicators* of the World Bank and then disaggregated using INTER procedure. The CPI and nominal exchange rates of the dollarized economies are collected from IFS.

REFERENCES

Agenor, P.-R., and M.S. Khan (1996), "Foreign Currency Deposits and the Demand for Money in Developing Countries," *Journal of Development Economics*, 50(1), 101-118.

Akçay, O.C., C.E. Alper, and M. Karasulu (1997), "Currency Substitution and Exchange Rate Instability: The Turkish case," *European Economic Review*, 41(3-5), 827-835.

Akofio-Sowah, N.A. (2009), "Is There a Link between Exchange Rate Pass-Through and the Monetary Regime: Evidence from Sub-Saharan Africa and Latin America," *International Advances in Economic Research*, 15(3), 296-309.

Bahmani-Oskooee, M. (1996), "Exchange Rate Uncertainty and Trade Flows of LDCs: Evidence from Johansen's Cointegration Analysis," *Journal of Economic Development*, 21(1), 23-35.

Bahmani-Oskooee, M., and I. Domac (2003), "On the Link between Dollarization and Inflation: Evidence from Turkey," *Comparative Economic Studies*, 45(3), 306-328.

Bahmani-Oskooee, M., H. Harvey, and S.W. Hegerty (2012), "Exchange Rate Volatility and Industry Trade Between the U.S. and Korea," *Journal of Economic Development*, 37(1), 1-27.

Bahmani-Oskooee, M., and S. Payesteh (1993), "Does Exchange Rate Volatility Deter Trade Volume of LDCs?" *Journal of Economic Development*, 18(2), 189-205.

Barrell, R., E.P. Davis, and O. Pomerantz (2009), "The Impact of EMU on Real Exchange Rate Volatility of EU Countries," *National Institute Economic Review*,

208, 101-108.

Bartram, S.M., and G.A. Karolyi (2006), "The Impact of the Introduction of the Euro on Foreign Exchange Rate Risk Exposures," *Journal of Empirical Finance*, 13(2006), 519-549.

Benita, G., and B. Lauterbach (2007), "Policy Factors and Exchange Rate Volatility: Panel Data versus a Specific Country Analysis," *International Research Journal of Finance and Economics*, 7.

Berg, A., and E. Borensztein (2000), "The Choice of Exchange Rate Regime and Monetary Target in Highly Dollarized Economies," *Journal of Applied Economics*, 3(2).

Berkmen, S.P., and E. Cavallo (2010), "Exchange Rate Policy and Liability Dollarization: What Do The Data Reveal About Causality?" *Review of International Economics*, 18(5), 781-795 (Available at http://www.blackwellpublishing.com/journal.asp?ref=0965-7576).

Brodsky, D.A. (1984), "Fixed versus Flexible Exchange Rates and the Measurement of Exchange Rate Instability," *Journal of International Economics*, 16(3-4), 295-306.

Bogetic, Z. (2000), "Official Dollarization: Current Experiences and Issues," *Cato Journal*, 20(2), 179-213.

Brock, W.A., W. Dechert, and J. Scheinkman (1996), "A Test for Independence Based on the Correlation Dimension," *Econometrics Reviews*, 15, 197-235.

Calvo, G., and C. Vegh (1992), "Currency Substitution in Developing Countries: An Introduction," *Revisita De Analisis Economico*, 7(1), 3-27.

_____ (1996), "From Currency Substitution to Dollarization: Analytical and Policy Issues," in Calvo G. ed., *Money, Exchange rates and Output*, MIT Press, 153-175.

Calvo, G., and C.M. Reinhart (2002), "Fear of Floating," *Quarterly Journal of Economics*, 117(2), 379-408.

Canales-Kriljenko, J., and K. Habermeier (2004), "Structural Factors Affecting Exchange Rate Volatility: A Cross-Section Study," International Monetary Fund Working Paper, WP/04/147.

Chan, W.S. (1993), "Disaggregation of Annual Time Series Data to Quarterly Figures: A Comparative Study," *Journal of Forecasting*, 12(8), 677-688.

Clark, P., N. Tamirisa, S.-J. Wei, A. Sadikov, and L. Zeng (2004), "Exchange Rate Volatility and Trade Flows: Some New Evidence," International Monetary Fund Research Paper.

Clements, B., and G. Schwartz (1993), "Currency Substitution: The Recent Experience of Bolivia," *World Development*, 21(11), 1883-1893.

Corrado, G. (2008), "An Open Economy Model with Currency Substitution and Real Dollarization," *Journal of Economic Studies*, 35(1), 69-93.

Dell, A.G., (1999), "Exchange Rate Fluctuations and Trade Flows: Evidence from the European Union," IMF Staff Papers, 46(3), 315 -334.

Devereux, M., and P. Lane (2003), "Understanding Bilateral Exchange Rate Volatility," Paper presented at the Empirical Exchange Rate Models Conference, Madison,

Wisconsin (Available at http://www.tcd.ir/Economics/TEP/2002_papers/TEPNo11PL22.pdf).

Ekanayake, A.W., and H. Tsujii (1999), "Real Exchange Rate Volatility and Sri Lanka's Exports to the Developed Countries," *Journal of Economic Development*, 24(1), 147-165.

Engle, R.F. (1982), "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation," *Econometrica*, 50(2), 391-497.

Fielding, D., and K. Shields (2003), "Economic Integration in West Africa: Does the CFA Make a Difference?" Discussion Papers, 03/8, University of Leicester.

Girton, L., and D. Roper (1981), "Theory and Implications of Currency Substitution," *Journal of Money, Credit & Banking*, 13(1), 12-30.

Gunther, S. (2009), "Exchange Rate Volatility and Growth in Emerging Europe and East Asia," *Open Economic Review*, 20(4), 565-587.

Hausmann, R., U. Panizza, and E. Stein (2001), "Why Do Countries Float the Way They Float?" *Journal of Development Economics*, *66*(2), 387-414.

Hausmann, R., and U. Panizza (2003), "On the Determinants of Original Sin: An Empirical Investigation," *Journal of International Money and Finance*, 22(7), 957-990.

Honig, A. (2009), "Dollarization, Exchange Rate Regimes and Government Quality," *Journal of International Money and Finance*, 28(2), 198-214.

Hviding, K., M. Nowak, and A.L. Ricci (2004), "Can Higher Reserves Help Reduce Exchange Rate Volatility," International Monetary Fund Working Paper, WP/04/189.

Kazunobu, H., and K. Fukunari (2009), "The Effect of Exchange Rate Volatility on International Trade in East Asia," *Journal of the Japanese and International Economies*, 23(4), 395-406.

Kenen, P.B., and D. Rodrik (1986), "Measuring and Analysing the Effects of Short-Term Volatility in Real Exchange Rates," *Review of Economics and Statistics*, 68(2), 311-315.

Komarek, L., and M. Martin (2001), "Currency Substitution in the Transition Economy: A Case of the Czech Republic 1993-2001," Working Paper, 613, Warwick: The University of Warwick, Department of Economics (Available at http://wrap.warwick.ac.uk/1573/1/WRAP_Komarek_twerp613.pdf).

Kyung-Chun, M. (2008), "Effects of Exchange Rate Fluctuations on Equity Market Volatility and Correlations: Evidence from the Asian Financial Crisis Images," *Quarterly Journal of Finance and Accounting*, 47(3), 77-102.

Lange, C., and C. Sauer (2005), "Dollarization in Latin America: Seigniorage Costs and Policy Implications," *The Quarterly Review of Economics and Finance*, 45(2005), 662-679.

McLeod, A.I., and W.K. Li (1983), "Diagnostic Checking ARMA Time Series Models Using Squared-Residual Autocorrelations," *Journal of Time Series Analysis*, 4, 269-273.

Mengesha, L.G., and M.J. Holmes (2011), "The Dollarization of Less Developed Countries: A Note on the Competition of Hard Currency Index," *International Journal of Economics and Research*, 2(2), 61-66.

Nelson, D. (1991), "Conditional Heteroskedasticity in Asset Returns: A New approach," *Econometrica*, 59, 347-370.

Nicolo, G.D., P. Honohan, and A. Ize (2005), "Dollarization of Bank Deposits: Causes and Consequences," *Journal of Banking & Finance*, 29(7), 1697-1727.

Rana, P.B. (1981), "Exchange Rate Risk under Generalized Floating: Eight Asian Countries," *Journal of International Economics*, 11(4), 459-466.

Reinhart, C.M., K.S. Rogoff, and M.A. Savastano (2003), "Addicted to Dollars," NBER Working Papers, 10015, Cambridge, Massachusetts: National Bureau of Economic Research (Available at http://www.nber.org/papers/w10015.pdf).

Rennhack, R., and M. Nozaki (2006), "Financial Dollarization in Latin America," IMF Working Paper, WP/06/7, Washington, D.C.: International Monetary Fund.

Savvides, A. (1996), "CFA Franc Zone Membership and Exchange Rate Variability," *Journal of African Economies*, 5(1), 52-68.

Schnabl, G. (2007), "Exchange Rate Volatility and Growth in Small Open Economies at the EMU Periphery," Working Paper, 773/July/2007, European Central Bank (Available at http://www.ecb.int/pub/pdf/scpwps/ecbwp773.pdf).

Taylor, M.P., D.A. Peel, and L. Sarno (2001), "Nonlinear Mean-Reversion in Real Exchange Rates: Toward a Solution to the Purchasing Power Parity Puzzles," *International Economic Review*, 42, 1015-1042.

Tsay, R.S. (1986), "Nonlinearity Tests for Time Series," *Biometrica*, 73, 461-466.

Viseth, K.R. (2001), "Currency Substitution and Financial Sector Developments in Cambodia," Working Paper, 01/4, International and Development Economics (Available at https://digitalcollections.anu.edu.au/bitstream/1885/40302/3/0502Viseth.pdf).

Yeyati, E.L. (2006), "Financial Dollarization: Evaluating the Consequences," *Economic Policy*, 21(45), 61-118.

Yinusa, D.O. (2008), "Between Dollarization and Exchange Rate Volatility: Nigeria's Portfolio Diversification Option," Journal *of Policy Modelling*, 30(5), 811-826.

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