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Abstract

While flexible exchange rates facilitate stabilisation, exchange rate fluctuations can cause real volatility. This gives policy importance to the causal relationship between exchange rate depreciation and its volatility. An exchange rate may be expected to become more volatile when the underlying currency loses value. We conjecture that a reverse causation, which further weakens the currency, may be mitigated by price stability. Data from Ghana, Mozambique and Tanzania support this: depreciation makes exchange rate more volatile for all but volatility does not causes depreciation in Tanzania which has enjoyed a more stable inflation despite all countries adopting similar macro-policies since early 1990s.

Keywords: exchange rate, depreciation, volatility, causality, GARCH, VAR

JEL Classification: E3, F3, F4,

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1. Introduction

The main purpose of this paper is to examine whether the time series behaviour of the exchange rate differs across LDC's with varying inflation uncertainty. We focus on the causality between exchange rate depreciation and its volatility. The policy relevance of this exercise is best explained in the context of the relationship between inflation and the exchange rate. Since Friedman's explanations on merits of floating versus pegging (Friedman, 1953), a country's exchange rate regime is believed to play a crucial role in transmitting the impact of real exogenous shocks. On the whole, there now seems to be general agreement that adopting a flexible exchange rate regime reduces the impact of shocks and enables monetary authorities to pursue their stabilisation policies more effectively. This is particularly important for LDCs with less advanced capital, financial and in particular currency markets and with more rigid demarcation between the composition of exports and imports. Broda (2004) documents the steep rise in the number of LDCs switching to the flexible rate regime and provides evidence that shows Friedman's hypothesis holds: when exposed to a real exogenous shock (i.e., a terms-of-trade shock), countries that float exhibit a significantly lower GDP volatility.

Under a flexible exchange rate regime, however, the nominal spot exchange rate fluctuates to clear the currency market and therefore has the potential to become too volatile.[1] As a result, the possibility that this volatility could feed back into the real economy has raised considerable concern and a large number of studies have examined the real impacts of exchange rate volatility. While the accumulated evidence is not totally conclusive[2], there is sufficient indication that exchange rate volatility can have significant real effects which are mitigated by price level stability: using data from 71 countries for the period 1979-2000, Choudhri and Hakura (2006) find that a significant positive association between the average inflation rate and the exchange rate effect exists across both countries and time.[3]

Our study of the causality between the exchange rate and its volatility is motivated by the above findings and mirrors the studies which examine the causal relationship between inflation and

[1] In fact, unlike what Friedman had envisaged, once they were free to float most exchange rates fluctuated far beyond what economists had initially anticipated. It is now widely accepted that this volatility phenomenon stems mainly from the 'asset price' characteristic of this variable, especially when speculators perceive opportunities in exploiting a currency.

[2] While some studies find exchange rate fluctuations to have little real effects (e.g., Baxter and Stockman, 1989), others report significant effects: Krugman (1991), Frankel and Wei (1993), Goldberg and Klein (1998) and Campa and Goldberg (2005, 2006).

[3] Taylor (2000), Devereux and Engel (2002) and Gagnon and Ihrig (2001), among others, show this theoretically; the latter also present evidence in line with Choudhri and Hakura (2006).

inflation uncertainty.[4] As Friedman (1977) explained, if policy makers show reluctance to reduce it, a rising inflation can lead to high inflation volatility/uncertainty. The same type of argument is pertinent for the relationship between the exchange rate and its volatility in those LDCs which have been floating their exchange rate but have not yet managed to sufficiently reduce and stabilise their inflation rate. The rationale is simple: the main reasons why a country floats its exchange rate are to eliminate the inflationary pressure and exogenous shocks due to pegging, and to free its monetary policy so as to better target inflation or implement stabilization policies. However, the mere knowledge that there is going to be no immediate intervention in the currency market renders the country's exchange rate vulnerable and an incident of depreciation can easily trigger future exchange rate volatility especially if there are doubts about the strength of country's foreign exchange reserves to stand speculative attacks. On the basis of what the literature suggests, one would expect in such circumstances to observe expenditure switching effects of exchange rate fluctuations and hence real volatility to ensue, which defeats the purpose behind floating the exchange rate in the first place. What matters most in such a situation is for the policy authorities to know whether the causation between exchange rate depreciation and volatility runs both ways, in which case a credible intervention in the currency market may be necessary in the interest of preventing a vicious circle of depreciation and volatility.

Our conjecture is that while it is not so uncommon to observe a significant positive causation from exchange rate depreciation to its volatility, the causality in the opposite direction is likely to vary with a country's inflationary experience. More specifically, we expect the reverse causality to occur in countries with a higher inflation uncertainty. To ascertain this, we analyse monthly time series data on the price level and the exchange rate (CPI and nominal spot rate) for the period 1990-2009 for Ghana, Mozambique and Tanzania. These countries have gone through comparable policy engagements with the IMF, have followed similar floating exchange rate regimes during this period and currently all adhere to the IMF convention of free current account convertibility and transfer.[5] However, Tanzania has had a relatively lower and more stable inflation in the last decade and we find that this is reflected in its exchange rate behaviour: Tanzanian shilling has depreciated much less and there is no significant causation from exchange rate volatility to its depreciation. In Section 2 we describe the main features of the series used in the analysis, apply the GARCH methodology to estimate the volatility of inflation and exchange rate, and explain the results of Granger-causality tests. Section 3 concludes the paper.

[4] Ball (1992) provides a theoretical explanation for this phenomenon on which now ample evidence exists: see, among others, Grier and Perry (1998), Nas and Perry (2000), Fountas (2001), Hwang (2001), Apergis (2004), Kontonicas (2004) and Daal et al. (2005).

[5] Ghana and Tanzania accepted Article VIII of IMF "Articles of Agreement" in 1994. Mozambique began floating in 1992 under the SAP reforms of IMF; Article IV consultation was completed in 2009 and acceptance of Article VIII seems imminent.

2. Data, volatility estimates and causality tests

We use monthly time series data for the period January-1990 to December-2009. The first row of Table 1 illustrates the behaviour of inflation series. Given our emphasis on stability, inflation rates, denoted by π_t, are the monthly percentage changes in domestic CPI relative to the US CPI. There is a clear change in the way inflation has fluctuated in these countries over the period, with the last decade showing more stable patterns in all countries; sample means (standard deviations) of π_t for 2000-2009 are: Ghana, 0.011796 (0.014530); Mozambique, 0.006198 (0.014142); Tanzania, 0.003624 (0.013268). To provide a better idea of inflation behaviour we examined its volatility, $\sigma^2_{\pi,t}$, as follows:[6] (i) We tested the time series properties of π_t and found it to be stationary but highly autocorrelated in all countries. (ii) We experimented with different ARMA specifications based on

$$\alpha(L)\alpha_s(L)\left(\left(1-L^m\right)\pi_t-\mu_t\right)=\beta(L)\beta_s(L)\varepsilon_t, \qquad (1)$$

where α, α_s, β and β_s are polynomials of adequate order in the lag operator *L*, subscript *s* denotes the seasonal component that can be factorised and together with m=12 captures any dynamics due to the months' effects, μ_t is a deterministic component which captures any mean-shifting across months with month-dummies, and ε_t is an independent zero-mean disturbance term. We selected a statistically robust and parsimonious empirical representation of the generating process for π_t for each country. (iii) The empirical representations obtained thus are conditional on the assumption of ε_t being homoscedastic. We tested the homoscedasticity assumption which was strongly rejected in all cases. We therefore generalized the selected models by augmenting them with a first order exponential GARCH process,

$$\ln\sigma^2_{\pi,t}=\phi_0+\phi_1\ln\sigma^2_{\pi,t-1}+\phi_2\left|\frac{\varepsilon_{t-1}}{\sigma_{\pi,t-1}}\right|+\phi_3\frac{\varepsilon_{t-1}}{\sigma_{\pi,t-1}}, \qquad (2)$$

which allows for an asymmetric uncertainty effect captured by ϕ_3: ceteris paribus, a positive shock is assumed to increase (reduce) volatility if $\phi_3>0$ ($\phi_3<0$) via strengthening (dampening) the ARCH effect. We found that in all cases estimates of the augmented model confirmed strong presence of ARCH effects and that (2) adequately captured the variations.[7] The estimated variances, $\hat{\sigma}^2_{\pi,t}$, are

[6] Statistical details are not reported here but are available upon request.

[7] Raising the order of the process in (2) or using other GARCH processes (power, threshold or component GARCH) did not lead to any improvement in any of the cases. For details on the formulation of GARCH models see, e.g., Ding et al. (1993) and Hentschel (1995).

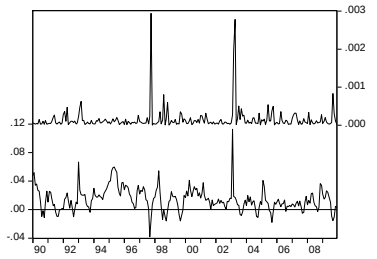
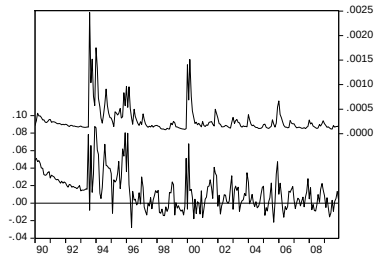
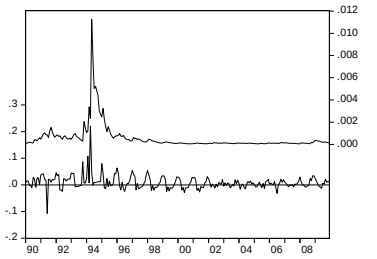
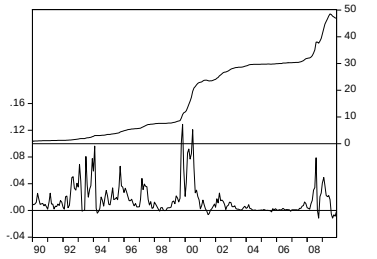
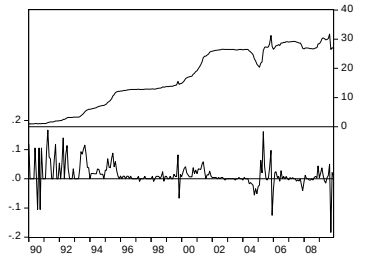
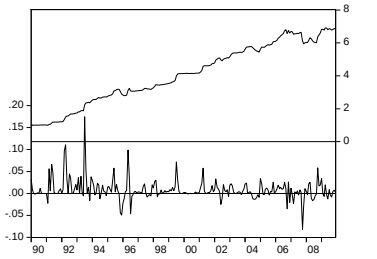
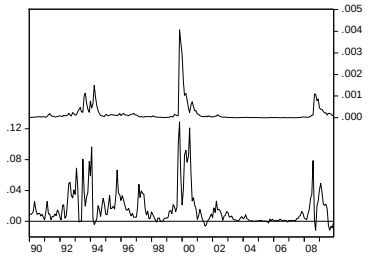
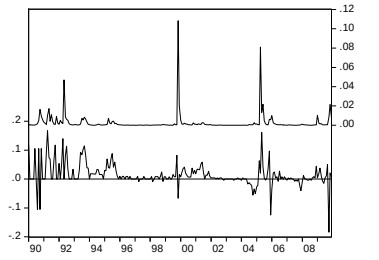
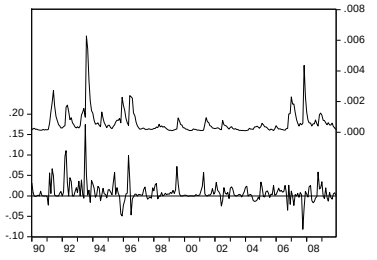
also plotted in the same figures in the first row of Table 1 and show that inflation in Tanzania has been relatively more stable in the last decade; sample means (standard deviations) of $\hat{\sigma}^2_{\pi,t}$ for 2000-2009 are: Ghana, 0.000165 (0.000321); Mozambique, 0.000221 (0.000199); Tanzania, 0.000111 (0.000045).

With this background, we examined the time series properties of the exchange rate whose level and volatility we denote by x_t and $\sigma^2_{x,t}$ respectively. The second row in Table 1 shows plots of x_t and $\Delta \log x_t$; unit root tests revealed that $\log x_t$ is I(1) and $\Delta \log x_t$ is stationary but highly autocorrelated in all countries. It is worth noting that whilst there has been persistent depreciation in all countries, Tanzania's shilling has depreciated much less and has enjoyed a more stable pattern over the last decade; sample means (standard deviations) of $\Delta \log x_t$ for 2000-2009 are: Ghana, 0.011657 (0.021859); Mozambique, 0.005057 (0.033068); Tanzania, 0.004244 (0.016131). We followed the same steps described above to obtain estimates of $\sigma^2_{x,t}$ which we plot in the third row of Table 1 and in the row below it we report the GARCH effects which show that whilst strong GARCH and ARCH effects are present in all countries, the latter effect is milder and is further dampened by a negative asymmetric effect in Tanzania.

In order to examine the nature of causality, for each country we estimated a vector autoregressive model (VAR) for $\left(\pi_t, \sigma^2_{\pi,t}, \Delta \log x_t, \sigma^2_{x,t}\right)$. Starting with a sufficiently long lag-length we used the sequential likelihood ratios and chose the appropriate lag-length for each country's VAR. We then tested the exclusion restrictions in each VAR implied by the corresponding Granger-non-causality null hypotheses "$H^1_0 : \Delta \log x$ *does not Granger-cause* σ^2_x" and "$H^2_0 : \sigma^2_x$ *does not Granger-cause* $\Delta \log x$", respectively. The test results together with the impulse responses (not reported but available upon request) showed that depreciation makes the exchange rate more volatile in all three countries, and that volatility feeds back to cause further depreciation in Ghana and Mozambique but not in Tanzania. The same conclusions were obtained from bivariate VARs involving only $\left(\Delta \log x_t, \sigma^2_{x,t}\right)$ and using both the above monthly series as well as daily series for the period 1-January-2001 to 31-December-2009.[8]

[8] This result is encouraging since daily series convey a more robust measure of volatility. These additional results are not reported here but are available upon request.

Table 1: Inflation Rate Volatility and Exchange Rate Behaviour [(i)]

	Ghana	Mozambique	Tanzania
Inflation Rate[(ii)]: % Δ in CPI and its Volatility			
	volatility, $\hat{\sigma}^2_{\pi,t}$ ***, on the right axis***	***volatility,*** $\hat{\sigma}^2_{\pi,t}$ ***, on the right axis***	***volatility,*** $\hat{\sigma}^2_{\pi,t}$ ***, on the right axis***
Exchange Rate[(iii)]: Level and % Δ			
	level, **1990 =1,** ***on the right axis***	***level,*** **1990 =1,** ***on the right axis***	***level,*** **1990 =1,** ***on the right axis***
Exchange Rate: % Δ and its Volatility			
	volatility, $\hat{\sigma}^2_{x,t}$ ***, on the right axis***	***volatility,*** $\hat{\sigma}^2_{x,t}$ ***, on the right axis***	***volatility,*** $\hat{\sigma}^2_{x,t}$ ***, on the right axis***
GARCH Effects for Exchange Rate[(iv)]	**EGARCH Coefficient Estimates**	**EGARCH Coefficient Estimates**	**EGARCH Coefficient Estimates**
	$\hat{\phi}_0 = -0.855^{***}$	$\hat{\phi}_0 = -2.355^{***}$	$\hat{\phi}_0 = -1.242^{***}$
	$\hat{\phi}_1 = 0.974^{***}$	$\hat{\phi}_1 = 0.825^{***}$	$\hat{\phi}_1 = 0.894^{***}$
	$\hat{\phi}_2 = 0.805^{***}$	$\hat{\phi}_2 = 1.349^{***}$	$\hat{\phi}_2 = 0.646^{***}$
	$\hat{\phi}_3 = 0$	$\hat{\phi}_3 = 0.180^{*}$	$\hat{\phi}_3 = -0.179^{**}$

(i) Data, originally provided by the IMF, were obtained from the US Department of Agriculture.

(ii) Inflation rates measure the percentage changes in CPI relative to the US CPI and inflation volatility series were estimated using the GARCH technique as described above.

(iii) Exchange rates are nominal spot rates corresponding to units of: Ghana cedi, Mozambique metical and Tanzania shilling per US dollar. Their volatility series were estimated using the GARCH technique as described above.

(iv) The GARCH coefficients correspond to those in equation (2); ***, ** and * denote significance at 1%, 5% and 10%, respectively.

3. Summary and conclusion

It is known that flexible exchange rate regimes facilitate macroeconomic stabilisation policies. But there is also evidence that exchange rate fluctuations cause real volatility, e.g., via their relative price and expenditure switching effects. Thus, any information pertaining to the nature of causality between a depreciation of exchange rate and its volatility can prove useful to monetary policy authorities. In general, it is not unfeasible to expect even a mildly persisting depreciation of exchange rate to raise its volatility. But the existence of the reverse causation is not so straightforward and we conjecture that it can be mitigated by price stability. To examine this conjecture we use data from three LDCs: Ghana, Mozambique and Tanzania. These countries were chosen because they adopted similar macroeconomic policies since early 1990s but Tanzania has enjoyed a relatively stronger currency and more stable inflation in the last decade. We find that, whilst depreciation makes exchange rate more volatile in all three countries, volatility causes depreciation only in Ghana and Mozambique. The intuition for this evidence may lie in the fact that policies resulting in more stable inflation establish credibility. As for the policy conclusion, it is tempting to draw a bold one: unless the policy freedom gained by floating the exchange rate is fully channelled to achieve a more credible and lasting price stability, exchange rate fluctuations could become too persistent and even a vicious circle of depreciation and volatility may ensue.

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