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DOCTOR OF PHILOSOPHY

Exchange rate volatility in LDCs
some findings from the Ghanaian, Mozambican and Tanzanian markets

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"Having endeavoured to forecast exchange rates for more than half a century, I have understandably developed significant humility about my ability in this area…"

Alan Greenspan,

Remarks before the Euro 50 RoundTable

Washington D.C., November 30, 2001

A Guide to this Thesis

Interest in the modelling of exchange rate volatility has remarkably increased in the post Bretton Woods era. This is because the current floating exchange rate system which is being used by many countries in determining the level of exchange rate is characterised by large unexpected volatile deviations from their fundamentals' determined equilibrium. Flood (1981), Meese and Rogoff (1983a and 1983b) and also Killian and Taylor (2003) observed that these large and unanticipated volatile deviations make exchange rate very difficult to predict especially in the short run. Modelling exchange rate volatility enables us to forecast uncertainties (volatility) that are associated with forecasts from exchange rate models.

Although exchange rate volatility is seen by many researchers to hold the potential in affecting the economic welfare of any nation, yet most of the studies on exchange rate volatility are focused mainly on developed and to an extent emerging markets with studies on Less Developed Countries (LDCs) almost non-existent. Exchange rate volatility is seen as a major influence on any LDC government's monetary policies, especially when export growth, imports, debts obligations, aid and foreign direct investment are contributory factors to their economic growth. In this thesis, we analysed nominal exchange rate volatility in three LDCs namely

Ghana, Mozambique and Tanzania. The reasons for using bilateral nominal exchange rates include;

- They are readily available (especially for LDCs) compared to other alternatives (real exchange rates-RER, real effective exchange rates-REER, and nominal effective exchange rates-NEER). In flexible exchange rate regime, nominal exchange rates and real exchange rates tend to move together in the short run. This means that there would be no significant difference in results if either is used in a trade model.
- Monthly (daily and even hourly) nominal exchange rates are easily available for most countries compared to the other alternative exchange rate measures. High frequency exchange rates allow us to estimate much more optimal volatility forecasts (see Andersen et al, 1999).
- For governments, fluctuation in the nominal exchange rate volatility would in turn influence the behaviour of short-term capital flow and which would in a way have an effect on net foreign assets; the result is a change in the volume of currency in circulation which would require prudent monetary policies to stabilize.

Summaries of the six main chapters of our thesis are as follows:

In Chapter One, we analysed the nature of exchange rate variability in the Ghanaian cedi against US dollar (GHC/USD), the Mozambican metical against the US dollar (MZM/USD) and the Tanzanian Shilling against the US dollar (TZS/USD). We observed that all three countries considered in our studies started operating an operational flexible exchange rate systems in the nineties after decades of currencies overvaluation, political instability, fixed exchange rates regimes, long periods of high inflationary rates and improper monetary and fiscal policies. We also

observed that exchange rate behaviour in the three LDCs under consideration is influenced by similar factors including external debts, foreign aid, import of manufactured and processed goods, and exports of primary commodities among others.

Previous literature suggests that mastering the art of volatility modelling involves the utilizing of the time series properties of the data of interest as well as the empirical regularities of financial market volatility (see Engle and Patton 2001 as well as Poon 2005). Many of these inherent common financial time series properties and empirical regularities were observed in studies in which data from highly traded currencies or exchange rates from developed countries were used. In Chapter Two, we investigated empirically if GHC/USD, MZM/USD and TZS/USD exhibit the above-mentioned properties. For each country, we used daily nominal bilateral exchange rate data from 01/01/2001 to 30/12/2005 and monthly data from 01/1995 to 12/2005. We found that exchange rate series for the three LDCs under consideration exhibit similar time series properties and empirical regularities observed in previous studies in exchange rate markets of developed economies and highly traded currencies. These findings therefore implies that volatility modelling and forecasting techniques that have been previously applied to previous studies can also be used on the Ghanaian, Mozambican and the Tanzanian nominal exchange rates. For instance, volatility models to be estimated should be able to cater for the non-linear and non-normal characteristics observed in the nominal GHC/USD, MZM/USD, and TZS/USD exchange rates. Also, the observed volatility clustering in the series under consideration implies that current volatility shocks (persistence) would influence the level of volatility many periods in the future. Asymmetry characteristics observed in our data suggests that volatility models that capture

positive and negative shocks differently can be applied to model the volatility in the three exchange rates under consideration.

A number of volatility measuring techniques such as EWMA (Exponentially Weighted Moving Averages) exist but none has arguably gained so many applications in research like the Engle's ARCH (Autoregressive Conditional Heteroscedastic) models and its other extensions. Engle's (1982) ARCH model revolutionized the art of volatility modelling to such an extent that even after more than two decades, the modelling technique remains very popular and shows no sign of waning. Bera and Higgins (1993) suggested the following for the ARCH success.

- ARCH family of models are simple and easy to handle.
- They take care of clustered errors.
- They take care of non-linearities in financial data.
- They take care of the econometrician's ability to forecast; that is the power of forecast changes as new information becomes available.

In Chapter Three, the econometrics of some ARCH family of models is discussed. In particular, we explained the different classes of popular members of the ARCH family of models, the properties of an ARCH process and estimation techniques that are applied in ARCH modelling. Also, in this chapter, the evaluation criteria which can be applied in the comparison of the forecasting performances of competing volatility models are explained.

In Chapter Two, we observed that the nominal GHC/USD, MZM/USD and TZS/USD exchange rate series exhibit the non-linear and non-normal data characteristics, as well as the empirical regularities associated with financial markets. As already suggested and supported by Bera and Higgins (1993) the ARCH modelling technique have been found in previous studies to accommodate these

properties. In Chapter Four, we empirically applied the ARCH modelling to analyse volatility in the daily and monthly nominal GHC/USD, MZM/USD and TZS/USD exchange rates. For each country we used daily series from 01/01/2001 to 30/12/2005 and monthly series from 01/1995 to 12/2005. These are the objectives we aimed to achieve in Chapter Four:

- Finding if we would need larger ARCH lags to estimate volatility in the GHC/USD, MZM/USD and TZS/USD nominal exchange rates (One of the main problem of ARCH models is that in practice, a large number of lags are required to model volatility in financial time series see Franke et al 2008, page 244 as well as Brooks 2008, page 452).
- Finding if the popular GARCH (1, 1) which have been observed in past studies (see Hansen and Lunde 2002) to adequately model volatility in most financial time series fits our three LDCs exchange rate series under consideration.
- Empirically substantiating that the three LDCs exchange rate series under consideration exhibit the inherent time series characteristics and the empirical regularities associated with exchange rate and other financial markets volatility.
- Comparing the forecasting abilities of our estimated ARCH family of models for each exchange rate series to forecasts from volatilities generated using an alternative estimation technique.

We observed that larger number of ARCH lags (ARCH (5) and ARCH (4)) were required to estimate daily nominal volatility in GHC/USD and TZS/USD exchange rates whereas an ARCH (2) appear to estimate daily nominal volatility in MZM/USD exchange rate. The simple ARCH (1) model however successfully

captured monthly nominal volatility in each of the three LDCs considered. Although we were able to model daily nominal volatility in GHC/USD, MZM/USD, and TZS/USD with the GARCH (1, 1) model, yet the same model did not produce a good fit for the GHC/USD and MZM/USD monthly series. The GARCH (1, 1) however modelled monthly nominal volatility in TZS/USD exchange rate. Previous daily volatility influence on future daily volatility in each of our three LDCs exchange rate series under consideration was observed to be asymmetric. In the corresponding monthly exchange rate series under consideration the presence of asymmetry depends on the series under consideration. We observed that the EGARCH (1, 1) was able to capture asymmetry in the conditional variance within Ghanaian and the Mozambican monthly exchange rate but the TARCH (1, 1) did not produce a good fit for both series. The TARCH (1, 1) was able to model conditional volatility on the monthly Tanzanian exchange rate under consideration. EGARCH (1, 1) however failed to produce a good fit. The observation of different volatile dynamics in same series but having different frequencies is not unusual. Diebold (1988) explained that volatility clustering and other features in exchange rate series that reflects market uncertainty tend to aggregate in low frequency data. Both daily and monthly exchange rate series for all three countries however suggest the presence of persistence.

We compared goodness of fit of our estimated ARCH family volatility models using the Mincer-Zarnowitz (1969) regression technique. Further, we compute period ahead volatility forecasts for each series under consideration and compare forecasting abilities using calculated Root Mean Square Errors (RMSE). We also compared our results to conditional volatility generated from an Exponential Weighted Moving Averages (EWMA) method similar to the JP Morgan

RiskMetrics™. We observed that our estimated ARCH family of models did not always produce the best fit and the best period ahead forecasts. For instance we observed that the EWMA model produced the best fit for the daily GHC/USD exchange rates. We also observed that the EWMA was judged to forecast a month ahead conditional variance in MZM/USD and TZS/USD exchange rates.

While flexible exchange rates facilitate stabilisation, exchange rate fluctuations can cause real volatility. This gives policy importance to the causal relationship between exchange rate and its volatility. An exchange rate may be expected to become more volatile when the underlying currency changes. We conjecture that a reverse causation, which further influence the value of the currency, may be mitigated by astute macro-policies. In Chapter Five we used the VAR toolkit to analyse relationship between daily GHC/USD, MZM/USD and TZS/USD and daily exchange rate uncertainty/volatility for the three LDCs under consideration. We generated exchange rate volatility for our period of study using asymmetric ARCH models estimated in Chapter Four. The asymmetric ARCH models were applied because they handle good news (innovations/shocks) and bad news as different inputs, and consequently, generate future conditional variance according to the sign of shock they identify in a data. We observe a bi-directional Granger causal relationship between changes in exchange rates and its associated uncertainty for all the three LDCs under consideration. Compared to Ghana and Mozambique, we find that shocks to exchange rate uncertainty from innovations in the level of Tanzanian exchange rate take a shorter length of time to decay. We attribute this to the macro-policies undertaken by the Tanzanian policymakers which have helped to ensure price and currency stability in our period of study. In the reverse Granger causal analyses, we observed that the effect of uncertainty feedback to exchange rate is

fleeting. We however conjectured from our results that whereas exchange rate intervention and other macro-policies might have contributed to quell market uncertainty in the Tanzanian market, the Ghanaian and Mozambican exchange rates markets however reacted with further uncertainty when stabilising policies are implemented.

In Chapter Six we analysed the relationship between trade and exchange rate volatility for Ghana, Mozambique and Tanzania and some of their biggest trading partners. Our main objectives for this study are;

- To establish if exchange rate volatility negatively affects bilateral trade in LDCs as suggested by Arize et al (2000) and Saur and Bohara (2001) for our period of interest.
- To establish whether country data, estimation technique and volatility proxies significantly affect our results (Baum and Caglayan 2006).
- Lastly, to ascertain whether the need to export primary goods and import manufactured goods by LDCs overrides other factors such as cost associated in trading (measured in terms of distance) as well as common language (which include cultural homogeneity and historical ties) that are known to affect bilateral trade (De Grauwe 1988) .

We focused our investigation in the post Bretton Woods era (specifically between 1980 and 2005). We also included other variables that are assumed to affect bilateral trade including incomes, populations, distances between trade partners and a dummy variable component to represent same language between trade partners in our empirical analyses. We generated three proxies of exchange rate volatility including an ARCH family generated volatility series, an EWMA generated volatility series and exchange rate volatility estimated as annualised monthly variance over the

period between 1980 and 2005 for each of the three LDCs. We applied a 'standard' time series cross-sectional gravity trade model for our analyses. We also controlled for heterogeneous trade relationship between each of the three LDCs and their respective trade partners by estimating fixed effects gravity model.

Similar to Baum and Caglayan (2006) we observed that the effect of volatility, population sizes, distance between trading partners and same language respectively on trade depends on the estimation technique applied as well as the volatility measure used. We however observed that Gross Domestic Product (GDP) as a measure of income positively and significantly influence bilateral trade irrespective of the estimation technique or the volatility proxy used. Analyses of fitness of models (based on R-Squares, AIC values and Durbin Watson statistics) suggest that the fixed effects gravity model estimate bilateral significantly better than the alternative 'standard' pooled gravity model for each of the three countries considered. Using the estimated fixed effects gravity trade models for our analyses, we observed that GDP (irrespective of the volatility measurement used) is positively related to bilateral trade for Ghana, Mozambique and Tanzania and their respective trade partners considered in this study. We further observed that earnings from trade increases as population increases for Ghana and Tanzania and their bilateral trade partners. In the case of Mozambique and her trade partners, we observed a negative and significant relationship between bilateral trade and population size. We also observed that for all three LDCs considered in our study, exchange rate volatility (irrespective of the measurement used), distance between trade partners and same language do not appear to influence bilateral trade for the period between 1980 and 2005