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Determinants of the exchange rate, its volatility and currency crash risk in Africa's low and lower middle-income countries

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Abstract

This paper investigates the determinants of nominal exchange rates, their volatility, and crash risk in Africa's lower and lower-middle income countries (LLMICs). It combines macro-panel estimations for 15 African LLMICs with floating or lightly managed exchange rates, with insights from 13 semi-structured interviews with 17 foreign exchange market participants in six case study countries. It shows the important role African LLMICs' distinct productive and export structure, concentrated in a few agricultural and mineral-based commodities, and recent financial integration for exchange rate determination. In particular, whereas productive factors such as terms of trade, export concentration, and export prices are found to have a significant impact on the exchange rate level and volatility, financial factors including the interest rate differential, international market conditions, and short-term financial flows, matter for the likelihood of currencies to experience sudden and large exchange rate movements.

[1] The views expressed in this document are the author's only and do not reflect the views of the Central Bank of Uganda.

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1 Introduction

The past three decades have witnessed substantial transformations in the foreign exchange markets of Low and Lower-Middle Income Countries (LLMICs) in Africa. Perhaps the most important changes have been the liberalization of the foreign exchange markets and capital accounts, and the move towards more flexible exchange rate regimes. Moreover, some countries have started to shift to monetary regimes that give higher priority to controlling inflation and use the interest rate as the main policy instrument. These changes have had important implications for exchange rate determination. The move towards more flexible exchange rate regimes has increased the magnitudes in nominal exchange rates and has increased their economic importance, both as macroeconomic price (through its implications for real exchange rate movements) and as factor in (international) investment decisions.[2] Moreover, whilst for many countries exchange rate movements are still largely the outcome of little diversified export structures and corresponding commodity prices, foreign exchange market and capital account liberalization have potentially increased the relevance of financial factors and international market conditions for exchange rate movements. These bring the risks of heightened exchange rate volatility and large and sudden exchange rate movements largely driven by conditions on international financial markets.

Despite the fundamental changes in foreign exchange markets in African countries and the central importance of the exchange rate for these economies, there is little systematic analysis of nominal exchange rate determination and currency crash risk in African LLMICs. This scarcity of studies is partly due to data availability and the short experience of nominal exchange rate flexibility in Africa, but also the assumption that exchange rates are driven by underlying fundamentals which vary little across time and space. The few existing studies on nominal exchange rate determination focus either on the short-run determinants of exchange rate volatility, or use time series data in selected African case studies (Deléchat and Gaertner 2008, Mpofu 2015, Daude, Yeyati et al. 2016). The panel data literature tends to pivot on the long-run determinants[3] of real exchange rates based on equilibrium exchange rate models (Combes, Kinda et al. 2011, Ricci, Milesi-Ferretti et al. 2013, Kataria and Gupta 2018), rather

[2] For international financial investments, both the returns on financial assets and the exchange rate constitute the international return. As the magnitude of nominal exchange rate movements has increased, so has their contribution to returns on domestic currency assets.

[3] Here the distinction is primarily whether authors work with the stationary returns of the series or the non-stationary levels and different types of cointegration analysis.

than the nominal exchange rate. The risk of sudden and large exchange rate movements (the crash risk) in the context of rising financial integration is a particular concern to the Bank for International Settlements (BIS). However, so far, no study has investigated the determinants of the level, volatility and the crash risk of the nominal exchange rate for a significant panel of African economies.

This paper fills this gap. It combines panel estimations of the determinants of the level, volatility, and crash risk for 15 African LLMICs with a sufficient degree of exchange rate flexibility, with in-depth semi-structured interviews with foreign exchange experts in six selected case study countries. Whereas the existing literature largely assumes that exchange rate determinants are the same for all countries, we pay particular attention to the potentially specific drivers of exchange rates in African LLMICs. In particular, we investigate the impact these countries' distinct productive, monetary, and financial characteristic have for exchange rate determination. Concerning the productive structure, this refers to African LLMICs' highly concentrated export structures, oftentimes limited to a few agricultural and mineral commodities. On the monetary/financial side, this includes the potentially large (and destabilising) impact foreign financial flows can have on the exchange rate in thin financial markets. Moreover, the sensitivity to international market conditions might be particularly acute in countries with a short track record of financial integration, weak currencies, and past experiences of financial and political turmoil (Barbosa, Jayme Jr et al. 2018).

To investigate these specific drivers, the paper triangulates results from 13 semi-structured interviews with 17 foreign exchange experts in Ghana, Kenya, Malawi, Sierra Leone, Uganda, and Zambia and the City of London with advanced panel data econometrics. The interviews aim at uncovering the relative importance of different exchange rate determinants according to local and international experts. They help to unearth potential determinants not yet considered in the literature and our research hypotheses, and those determinants which cannot be easily measured (either due to inherent immeasurability or lack of data). Panel-data techniques are then used to estimate the economic and statistical significance of potential exchange rate determinants for 15 African LLMICs for the period 1997-2019. To estimate the determinants of the exchange rate level and volatility, the paper applies the Augmented Mean Group Estimator, which accounts for several issues inherent to macro-data, such as slope heterogeneity, cross-sectional dependence, as well as the non-stationarity of the variables. We check robustness of the AMG results with Panel Dynamics Ordinary Least Squares (DOLS)

regressions and panel data with fixed effect estimated in first difference. To estimate the determinants of the crash risk we use quantile panel regression methods.

The interviews showed that balance of payments flows, in particular countries' main export commodities, remain a key determinant of the exchange rate in African LLMICs. In some countries, such as Uganda and Ghana, short-term speculative flows and international market conditions have assumed increased importance. Moreover, the interviews indicated the substantial pressures from governments' fiscal and public debt situation on exchange rates, and the key role central banks continue to assume in African foreign exchange markets.

These results, in particular the key role of African LLMICs distinct productive structures and increasing role of financial factors for exchange rate determination, were confirmed in the macro-panel estimations. Whereas an increase in the terms of trade, export concentration, and climatic vulnerability depreciated exchange rates across all estimations, an improvement in countries' export commodity prices appreciated them. The importance of these productive factors also held for exchange rate volatility. Here, an increase in export concentration and climatic vulnerability increased exchange rate volatility, whereas an improvement in the terms of trade reduced it. The impact of financial and monetary factors, on the other hand, was found to be less consistent for the exchange rate level and volatility: whereas a positive interest rate differential with the US and a rise in the VIX – as an indicator of international market conditions - had a significant depreciating effect on the exchange rate level, private financial flows (banking and portfolio) seemed to matter less. This, however, changed for the estimations of African LLMIC currencies' crash risk. Here, the productive factors were found to be less important, whereas financial factors, including the interest-rate differential, international risk aversion, and short-term financial flows had a strong impact on the risk of medium-sized and large exchange rate depreciations.

In addition to these main variables of interest, several other variables were found to matter for exchange rate determination in African LLMICs. These included, in particular, other balance of payments flows (such as the current account, FDI, overseas development aid, and remittances), and macroeconomic variables (in particular inflation and to a lesser extent GDP). Several institutional and political variables, such as trade openness, financial development, and corruption, were also found to be significant, mostly with a depreciating effect on the exchange rate.

The significance of the paper is two-fold. First, it contributes to improving the economic intelligence and the management of financial risk, especially currency risks for international institutional investors such as the European Investment Bank (EIB), specifically in their refinancing programs to local banks in African, Caribbean and Pacific (ACP) countries in local currency. Second, it contributes to improving the early warning toolkit available to policymakers in handling exchange rate instability. This is particularly important for LLMICs which are characterised by higher financial monetary risks and for which exchange rate determination differs fundamentally from those in high-income and upper-middle income countries, given their specific economic and financial structures and integration in the global economy.

The paper is structured as follows. Section 2 briefly presents the theoretical and empirical literature review underpinning this study. Section 3 discusses the methodology and data, and Section 4 presents the results. Section 5 concludes with some potential implications of our findings.

2 Review of the Literature

2.1. Theoretical Considerations for Exchange Rate Determination in LLMICs

Empirical investigations of nominal exchange rate determination in LLMICs are very scarce. This is particularly the case for Africa. If LLMICs are considered, they are mainly integrated into more extensive cross-country and panel studies for middle or even high-income countries. This is partly due to a lack of data (Di Bella, Lewis et al. 2007). Conceptually, however, this might also be related to the fact that in traditional macroeconomic exchange rate theory, the exchange rate is considered a market-clearing price, which means permanent underlying fundamentals determine exchange rates, both across time and space (Lyons 2001, Harvey 2009).

The recent microstructure literature has shown though that rather than adjusting to underlying macroeconomic fundamentals, exchange rates are driven by the buying and selling decisions of key actors in the respective foreign exchange market (Lyons 2001, Evans and Lyons 2002, Sarno 2005, Baccetta and van Wincoop 2006, De Grauwe and Grimaldi 2006). This means exchange rate drivers are necessarily context and time specific depending on the dominant foreign exchange flows and the way these are intermediated by key actors in the foreign

exchange market. Importantly, these microstructural effects do not only hold in the short-term but have permanent effects on exchange rates. As Lyons (2001: 12) puts it: "Whether we like it or not, it is a stubborn fact that in the major currency markets, there is no exchange rate other than the price these people set ".

In this context, a growing conceptual (Prates and Andrade 2013, Kaltenbrunner 2015, Bonizzi 2017) and empirical literature (Barbosa, Jayme Jr et al. 2018, Goda and Priewe 2020) has shown that exchange rate determination in emerging economies differs fundamentally from that in developed ones. For example, emerging economy currencies tend to be more dependent on yield-seeking, speculative capital flows (the carry trade) and experience a higher sensitivity to international market conditions (Heath, Galati et al. 2007, Kohler 2010). Moreover, given these countries' inability to borrow in domestic currency and less liquid domestic financial and currency markets, foreign currency denominated debt (their so called "original sin") and/or the stock of foreign investments in domestic currency assets (a vulnerability which the BIS recently denominated as "original sin redux"), might be key drivers of exchange rates in these countries (Chang and Velasco 1998, Hofmann, Shim et al. 2020).

However, so far this literature has largely focused on emerging economies with a significant degree of financial integration and exposure to international financial flows. Exchange rate determination might differ again in LLMICs given their thinner financial and foreign exchange markets, different productive structures, and nature of financial integration. For example, many African LLMICs continue to be characterised by a highly concentrated production and export structure, dependent on a few export commodities (largely agriculture and mining). At the same time, narrow tax bases and immense development needs, continue to exert structural pressures on the financing needs of African governments. Thus, as Okot (2021) argues, for these economies their asymmetric integration into the global productive system, as primary providers of commodities, might interact with the monetary and financial asymmetries discussed above and further destabilize exchange rate movements.

2.2. Empirical Literature on Nominal Exchange Rate Determination in LLMICs

So far, large parts of the existing empirical panel literature has focused on the determinants of the real exchange rate, rather than the nominal one, across large samples of developing (and indeed developed) ones. For example, Ricci, Milesi-Ferretti et al. (2013) investigate a panel cointegrating relationship between the REER and fundamentals for a sample of 48 developed

and developing countries from 1980 to 2004 using dynamic ordinary least squares (DOLS). Their findings show that while the net foreign assets position and trade liberalisation are associated with a real exchange rate depreciation, the productivity of tradables relative to non-tradables, commodity terms of trade, government consumption to GDP, and the elimination of administered prices appreciate the real exchange rate. Kataria and Gupta (2018) estimate a panel DOLS for 20 emerging economies with quarterly data from 2000 to 2015 and find that higher GDP growth, oil price increases, and domestic interest rates cause REER appreciation. An increase in international risk aversion, on the other hand, leads to an exchange rate depreciation; an impact which is muted by the existence of a more flexible exchange rate regime. Goda and Priewe (2020) study the determinants of REER movements in 15 emerging market economies with quarterly data from 2002 to 2016 using a dynamic panel fixed-effect model. The authors find that the commodity net export price index, variations in reserve assets, and Standard and Poor's rating are associated with a depreciation of the real exchange rate. On the other hand, real GDP growth, financial account liabilities as a share of GDP, and current account balance to GDP are associated with an appreciation of the real exchange rate.

In an alternative approach which puts analytical emphasis on the impact of financial and monetary factors on the real exchange rates, Barbosa, Jayme Jr et al. (2018) analyse the determinants of the REER in 45 developing and emerging economies (DEEs) using fixed and random effects panel data models with annual data from 1990 to 2008. The authors show that rather than by traditional macroeconomic fundamentals, exchange rates from DEEs are instead driven by short-term returns and capital flows, international market conditions, and their outstanding external obligations approximated by their gross short-run liabilities plus external debt as a share of foreign exchange reserves, and the current account balance as a share of GDP. In a similar vein, Mahraddika (2020) demonstrates the importance of incorporating financial sector variables in addition to traditional macroeconomic fundamentals into REER estimations. Using a DOLS model for 53 developing countries from 1980 to 2014, the author finds that government expenditure, productivity and net foreign assets appreciate the REER over the sample period. Combes, Kinda et al. (2011) study the effect of different capital flows on the REER for 42 emerging and developing countries from 1980 to 2006 and find that portfolio investment flows have the most substantial effect appreciating the real exchange rate, followed by foreign direct investment and bank loans.

The only study we are aware of that focuses specifically on real exchange rate determination in LLMICs is Prati, Ricci et al. (2011). The authors use a sample containing 134 countries (41 LICs and 36 LMICs) from 1980-2006 to analyse the long-run relationship between the REER and a set of fundamentals specific to LLMICs. Using DOLS with fixed effects, they show that whereas aid inflows are associated with exchange rate depreciation in the long-run, capital account liberalisation is consistent with exchange rate appreciation. To our knowledge, there is no paper, yet which estimates the determinants of the nominal exchange rate for a panel of LLMICs.

This is also the case for the panel literature which focuses specifically on African LLMICs. For example, Aydin (2010) assesses the degree of overvaluation/undervaluation of the REER for a sample of 182 countries from 1973 to 2014. Results show that only the terms of trade (appreciating), productivity (appreciating), and aid flows (depreciating) affect the real exchange rate in SSA. In non-oil exporting economies, the impact on the terms of trade is weakened, but productivity and aid inflows strengthened. Ahmad and Pentecost (2009) explore the determinants of bilateral real exchange rate fluctuations in 9 African countries (Algeria, Botswana, Egypt, Ghana, Kenya, Morocco, Nigeria, South Africa and Tanzania) using a trivariate structural vector autoregression (VAR) model with quarterly data from 1980 to 2005. Their results show that, for all the countries, real exchange rate movements in their sample are predominantly explained by demand shocks (i.e. fiscal policy). However, in countries like Botswana and South Africa, monetary shocks also play a significant role determining real exchange rate variations possibly explained by the degree of financial development in South African and Botswana's crawling peg to the rand. In addition, in Algeria, Egypt and Tanzania, supply shocks (i.e. structural reforms) play a significant role explaining real exchange rate variations.

Another strand of literature has investigated the importance of capital inflows for real exchange rate dynamics in SSA from different angles. For example, Lartey (2008) shows for 16 SSA economies from 1980s to 2000 using static, fixed-effects, and dynamic GMM panel estimations that official development aid inflows appreciate the real exchange rate in a greater magnitude than does FDI. Nwachukwu (2008) studies the relationship between the bilateral real exchange rate against the US Dollar and external finance in 24 SSA countries using a three-stage least squares (3SLS) estimation method and annual data from 1978 to 2001. The general finding is that external aid flows appreciate the real exchange rate and the total net capital inflows had an

impact over relative domestic prices. Similarly, Mongardini and Rayner (2009) use panel data techniques to estimate the relationship between grants, remittances and the equilibrium REER in 36 SSA countries from 1980 to 2006. They apply a pooled mean group (PMG) estimator to account for the long-run movements of the real exchange rate, which is expected to be homogeneous among the countries in the sample while considering short-term heterogeneous shocks. Results show that aid as a share of GDP is associated with a depreciation in the real exchange rate, while remittances are not statistically significant.

The only study so far which has considered nominal, rather than real exchange rate dynamics, in a panel context is Thomas (2012). The author investigates both bilateral nominal exchange rate movements against the US Dollar and the nominal effective exchange rate in the short and the long run using panel data techniques and monthly data from 2003 to 2010 for 12 SSA countries with officially floating exchange rate regimes[4]. In the short-run, exchange rate dynamics are expected to be determined by uncovered interest parity, whereas purchasing power parity is expected to hold in the long-run. Results show that an increase in the US treasury bills rate, the Emerging Markets Bonds Index (EMBI) spread, the euro-dollar exchange rate, and domestic inflation are associated with a depreciation of the nominal exchange rate. An increased in foreign exchange reserves, on the other hand, is associated with an appreciation of the nominal exchange rate.

With regards to exchange rate volatility, we are not aware of any panel study which focuses on LLMICs only. Several authors have analysed large panels including LLMICs (Calderon, Chong et al. 2002, Hausmann, Panizza et al. 2006, Grossmann, Love et al. 2014, Cevik, Harris et al. 2017) and find that the most important determinants of exchange rate volatility are output (real GDP, output shocks), reserves (foreign reserves, M2), interest rate (interest rate changes, monetary shocks), and financial factors (financial openness, external financial linkages, external financial liabilities). The only panel study which investigates nominal exchange rate volatility in SSA is Bangaké (2008) who shows for a panel of 21 SSA countries from 1990 to 2003 that exchange rate volatility is explained by variables such as the business cycle, the dissimilarity in the commodity structure of exports, and trade linkages.

Finally, as of yet, there are no panel studies which investigate explicitly the crash risk of LLMIC or SSA currencies. Frankel and Saravelos (2012) provide an overview of the most

[4] The study includes Gambia, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Rwanda, Sierra Leone, South Africa, Tanzania, Uganda, and Zambia.

common variables in the general literature to study the crash-risk determinants in emerging and developing countries and find that reserves, the real exchange rate, GDP, credit, the current account, money supply, exports or imports, inflation, equity returns, real interest rate, debt composition, budget balance, terms of trade, contagion, political/legal variables, capital flows, and external debt are among the most important variables to explain the crash risk. For SSA, Rogoff and Reinhart (2003) largely link currency crashes to incidences of high inflation.

In sum, whereas a considerable literature has focused on real exchange rate determination in UMICs and LMICs in general (Tables A1a and A1b in the Appendix summarise the main exchange rate determinants found to be significant in that literature), we know very little about the specific drivers of exchange rates in African LLMICs specifically. This is particularly the case for nominal exchange rates, in its level, but also volatility and crash risk. Moreover, we are not aware of any study which combines qualitative insights form foreign exchange experts in the respective countries, with macro-panel econometrics. In the remaining sections, this paper aims to address this gap.

3 Methodology and Data

This paper pursues a mixed-method study combining insights from panel econometrics with 15 African LLMICs boasting a sufficient degree of nominal exchange rate flexibility (officially floating or managed floating exchange rate regime), with semi-structured expert interviews in six case study countries. Whereas the interviews are aimed at uncovering the specific exchange rate drivers in the African LLMIC context, including those that cannot be measured, the panel data econometrics tests for their economic and statistical significance over time.

3.1 Semi-structured interviews

We conducted 13 semi-structured interviews with 17 foreign exchange experts in Ghana, Kenya, Uganda, Zambia, Sierra Leone, Malawi, and the City of London. The experts included eight representatives from central banks, three representatives from commercial banks, one asset manager, and three experts from research institutions and development agencies in Africa. In the City of London, interview partners consisted of one asset manager and one chief economist at a major international bank specialising in frontier markets. The case studies have been chosen to have a relatively varied sample with regards to income/capita, geographical location, and degree of integration into global financial markets. The interview participants

were sampled purposively given their specific expertise and position in the foreign exchange market. Interview participants were approached based on existing contacts, publicly available contact information, and snowballing.

The interviews were conducted in a semi-structured manner, meaning that a structured set of questions were followed; however, deviations from the exact order of questions and indeed sometimes from the exact wording of questions were tolerated. Given that the focus was on the expertise of our interview partners, all questions were open ended (Foddy 1993). We inquired directly into what respondents thought were the key drivers of exchange rates in African LLMICs/the respective country and - if they took active positions in the exchange rate - which variables they considered to form their own expectations. All interviews were conducted virtually on Zoom and lasted approximately 45-60 minutes. Interviews were transcribed, coded, and analysed using NVivo.

3.2 Panel Data Models

The semi-structured interviews were complemented with a macro-panel data study of the determinants of the level, volatility, and crash risk of 15 African LLMICs with officially floating or lightly managed floating exchange rate regimes (see Appendix 2 for details on the countries' official and de-facto exchange rate regime, their official monetary policy framework, and their degree of capital account openness). Specifically, we implemented two panel techniques taking into account the nature of the dependent variable: (a) the Augmented Mean Group model (AMG) proposed by Eberhardt and Bond (2009) and Eberhardt and Teal (2011) for the exchange rate level and the volatility, and (b) the quantile panel regression approach for the crash risk.

The AMG estimator was chosen because of its ability to account for potential non-stationarity, slope heterogeneity, and cross-sectional dependence in the data. Moreover, it works well in panels with moderate-T and moderate-N. It solves the cross-sectional problem by including as additional regressors what has been referred to as the 'common dynamic process' (CDP), which represents the levels-equivalent mean evolvement of unobserved common factors across all countries.

To estimate the crash risk, we use quantile regressions. Unlike the classical approach, which estimates the conditional mean value of the dependent variable for the given independent

variable, the quantile estimator is typically employed on different quantiles of the conditional distribution or the conditional quantile of the dependent variables for the given independent variables. One key advantage of quantile regression is that the method allows for understanding relationships between variables outside of the mean of the data, making it useful in understanding outcomes that are non-normally distributed and that have nonlinear relationships with predictor variables. Quantile regression allows the analyst to drop the assumption that variables operate the same at the upper tails of the distribution as at the mean. As such, quantile regression is more robust in nature and is able to capture outliers effectively (Koenker, Jr. and Bassett, 1978).

Another advantage of the quantile regression model is that it allows the researcher to account for unobserved heterogeneity and heterogeneous covariates effects, and at the same time because of its panel data nature, it can potentially allow for inclusion of fixed effects to control for some unobserved covariates (Canay, 2011). Typically, quantile methods allow for relaxing the common regression slope assumption. Thus, it provides an alternative to ordinary least squares (OLS) regression and related methods, which typically assume that associations between independent and dependent variables are the same at all levels.

We conducted two types of pre-tests to guide the selection of the above panel approaches. The first are tests of cross-sectional dependence, namely the Pesaran (2003) cross-sectional dependence (CD) test and Pesaran' (2004/2015) cross-sectional dependence (CD) test. The second type of pre-tests comprises a range of panel unit root tests, including both the first-generation and the second-generation approach. In the first-generation approach, we implement the Im-Pesaran-Shin (IPS) and Fisher- Type unit root tests. In the second-generation approach, which accounts for cross-sectional dependence in the variables, we implement Pesaran's (2003) unit root test which is based on the Dickey–Fuller regression augmented with the cross-section averages of lagged levels and first differences of the individual series (see Appendix 3 for detailed results).

3.2. Data Description and Preliminary Data Analysis

Our analysis covers in total fifteen African LLICM (Ghana, Kenya, Uganda, Zambia, Sierra Leone, Malawi, Egypt, Ethiopia, Tanzania, Gambia, Madagascar, Mauritania, Mozambique, Nigeria and Rwanda). The choice of countries is guided by data availability and exchange rate regime. Specifically, we excluded countries with fixed exchange rate regimes, as well as

countries in a monetary union (both the ECOWAS and the South and Western African Union). Based on data availability, an annual sample from 1997 to 2019 was selected.

For estimating the determinants of the exchange rate level, we use bilateral, nominal exchange rates to the US Dollar given the Dollar's dominant role in the region. The exchange rate level is normalized by creating an index using 1996 as base year, which is the year when most countries in the sample started opening up their countries to capital flows and adopted a more flexible exchange rate regime. The exchange rate is expressed with the US Dollar as the denominator, which means an increase in the exchange rate indicates a depreciation of the domestic currency. For estimating exchange rate volatility, we use the annualized monthly standard deviation. For estimating the currency crash risk using panel quantile regressions, we use the annualized monthly exchange rate change or depreciation compared to the previous month.

The potential exchange rate determinants are chosen based on our guiding research hypotheses (the role of African LLMICs' specific productive/export structure and nature of monetary and financial integration for exchange rate determination), the interview results, and data availability. In our core model, we include indicators of Africa' productive structure (terms of trade, the concentration of domestic exports, and national commodity price indices), financial and monetary integration (portfolio flows, other investments, and the yield differential with the US), and two macroeconomic variables as controls (inflation and GDP growth).

We extend the core model with other potential exchange rate determinants of interest informed by the existing literature and the interviews. These variables include: other balance of payments flows (the current account and foreign direct investment), other productive indicators (the climatic vulnerability indicator), public finance indicators (overseas development aid, external debt, remittances, foreign exchange reserves), institutional and political factors (trade openness, financial development, control of corruption, and political stability), and indicators of international market conditions (the VIX, and the global commodity and oil price index).[5] The additional variables are included alternatingly in the model to control for multicollinearity and omitted variable bias, without over-parametrizing our model.

[5] As discussed above, these global indicators also reflect Africa's specific integration into the global financial system. However, these common factors drop out in the AMG estimation and therefore can only be considered in the quantile regression (see also discussion below).

Most of the country-specific data are taken from the IMF's International Financial Statistics and World Bank Development Indicators, except the climatic vulnerability index and the productivity index which were obtained from the University of Notre Dame and the Conference Board of Total Economy Database respectively. The global factors are extracted from the Federal Reserve Economic Data. The exchange rate index, the terms of trade, the export commodity price index, and productivity are converted into natural logarithms. Table 1 summarises the explanatory variables, their measurement, and source.

Table 1. Variables, Descriptions, and Data Sources

Variable		*Abbreviation*	*Definition*	*Source*
Dependent Variables	Log exchange rate-normalized	Fx	Log of official exchange rate- normalised by creating exchange rate index with 1994 as the base year	IMF
	Volatility	Vol	Exchange rate volatility measured as the annualised standard deviation from monthly exchange rate changes	
	Crash-risk	Crash risk	Defined as the depreciation of the nominal exchange rate compared to the previous period	
Core Model				
Productive Factors	Terms of trade (log)	ToT	Terms of trade index	IMF
	Export concentration index	ECI	Normalized Herfindahl Concentration Index of exports	OECD
	Commodity export price index (expressed in log)	ECPI	Commodity Export Price Index, Individual Commodities Weighted by Ratio of Exports to Total Commodity Exports	OECD
Private Financial Factors	Yield Differential	Yielddiff	Yield Differential (difference between 3-month domestic treasury bill and 3-month US treasury bill)	IMF
	Other investment	Otherinv	Other investment, net (% of GDP)	IMF
	Portfolio investment	Portfolioinv	Portfolio investment, net (% of GDP)	World Bank
Macroeconomic Variables	Inflation	Inflation	Inflation, CPI (% change)	World Bank
	GDP growth	GDP	GDP growth (annual %)	World Bank
Control Variables				
Other Balance of Payments Flows	Current account balance	Cab	Current account balance (% of GDP)	IMF
	Foreign direct investment	FDI	Foreign Direct Investment (% of GDP)	World Bank
Other Productive Factors	Climatic vulnerability	Climaticvul	Climatic Vulnerability Index	University of Notre Dame
Public Finance	Official development assistance and official aid	ODA	Official development assistance and official aid received, net (% of GDP)	World Bank
	External debt	Debts	External debt (% of GDP)	World Bank
	Remittances	Remittance	Personal remittances received (% of GDP)	World Bank
	Reserves	Reserve	Total foreign reserves (% of total external debt)	World Bank
Institutional and Political Factors	Trade Openness	Openness	The openness of the economy, represented by trade openness index	IMF
	Financial Development	Financialdev	Financial Development Index	IMF

	Control of corruption	Corruption	Control of Corruption (Estimate)	World Bank
	Political stability	Politicalsta	Political Stability (Estimate)	World Bank
Global Factors	Vix	VIX	CBOE Volatility Index: VIX, Index, Annual, Not Seasonally Adjusted	Federal Reserve Economic Data
	Commodity price index	Commoditypri	Global Price Index of All Commodities, Index 2016 = 100, Annual, Not Seasonally Adjusted	Federal Reserve Economic Data
	Oil price index	Oilprice	Global price of APSP crude oil index, Index 2016 = 100, Annual, Not Seasonally Adjusted	Federal Reserve Economic Data
	US Treasury Bills	Ustbill	US 3-Month Treasury Bill Rates	Federal Reserve Economic Data

As can be seen in Table 2, the sample is unbalanced, with a maximum of 330 observations. The nominal exchange rate index varies between a minimum of 0.2 and a maximum of 7931.63 index points, with a standard deviation of 1194.816. Other variables with large standard deviations are the current account (from -65% to 21.5%), GDP growth (from – 20.6% to 26.4%), and inflation (from -8.24% to 44.78%). This confirms not only the heterogeneity among countries, but also that important changes have taken place within countries during the period considered.

Table 2: Summary Statistics

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Fx	330	*683.03*	*1194.82*	*0.20*	*7931.63*
Yielddiff	329	10.42	8.03	-15.59	40.50
ToT	326	4.64	0.39	3.51	5.73
Reserve	317	10.11	4.40	1.24	28.16
ECI	274	0.19	0.14	0.00	0.79
ECPI	330	4.33	0.35	2.82	4.86
Openness	330	54.05	21.01	11.08	132.49
Inflation	330	9.64	7.09	-8.24	44.76
Cab	330	-6.45	8.35	-65.00	21.50
Debts	330	54.10	42.82	4.18	215.28
FDI	330	4.17	5.14	-0.20	39.46
GDP	330	5.33	4.13	-20.60	26.42
ODA	330	10.01	7.10	0.01	44.17
Otherinv	330	0.27	3.47	-15.64	21.85
Portfolioinv	329	-0.29	1.91	-16.19	9.62
Remittance	293	2.38	2.57	0.02	15.23
Financialdev	316	0.12	0.06	0.00	0.45
Corruption	289	-0.60	0.36	-1.43	0.76
Politicalsta	288	-0.52	0.71	-2.21	0.83
Climaticvul	330	0.53	0.04	0.44	0.59
VIX	330	20.30	6.01	11.09	32.69
Ustbill	330	2.53	2.16	0.23	6.54
Commoditypri	330	107.76	43.86	47.31	182.47
Oilprice	330	124.02	60.80	31.28	222.45

Turning to the interaction between the explanatory variables, we conduct a pair-wise correlation analysis for the sample. The correlation matrix in Table 3 indicates that there is moderately high correlation of -0.68 between the current account and FDI. Current account balance and openness also have a correlation of -0.53. FDI and openness also have a high correlation of 0.67. The individual country's export commodity price index is highly correlated with both the global commodity price index and the global oil price index, with a magnitude of 0.77 and 0.73 respectively, while the global commodity price index and the global oil price index have the highest correlation of 0.99. The correlation between external debts and official development assistance of 0.42, and between the control of corruption index and political stability index of 0.49 can also be considered moderately high. This indicates that not all variables can be included simultaneously in the model as it may cause multicollinearity. This multicollinearity problem is also confirmed by the Variance Inflation Factor (VIF) test, a technique that provides a measure of multicollinearity among the independent variables in a multiple regression model (results presented in Appendix 3).

Table 3: Correlation Matrix for Selected Variables

	Cab	*FDI*	*Openness*	*ODA*	*Debts*	*FDI*	*ECPI*	*Commodity price*	*Oilprice*	*Climaticvul*	*Corruption*	*Politicalsta*
Cab	1											
FDI	-0.68	1.00										
Openness	-0.53	0.67	1.00									
ODA	-0.33	0.06	0.05	1.00								
Debts	-0.27	0.22	0.30	0.42	1.00							
ECI	-0.68	1.00	0.67	0.06	0.22	1.00						
ECPI	-0.23	0.20	0.23	-0.16	-0.48	0.20	1.00					
Commodityprice	-0.21	0.25	0.32	-0.22	-0.51	0.25	0.77	1.00				
Oilprice	-0.20	0.26	0.32	-0.21	-0.49	0.26	0.73	0.99	1.00			
Climaticvul	-0.19	0.04	0.13	0.41	0.24	0.04	-0.08	-0.02	-0.02	1.00		
Corruption	-0.11	0.02	0.07	0.16	-0.05	0.02	0.17	0.06	0.05	-0.13	1.00	
Politicalstab	-0.29	0.23	0.44	0.25	0.22	0.23	0.13	0.00	0.00	0.26	0.49	1.00

The panel unit root tests (also shown in Appendix 3), in particular the second-generation Pesaran (2003) test, confirm that our variables are of mixed order of integration. Also, both the Pesaran (2003) and the Pesaran (2004/2015) CD test suggest the presence of cross-sectional dependence in the model for the exchange rate level and volatility at the 1% level of statistical

significance. The existence of cross-sectional dependence and mixed order of integration justify the use of the Augmented Mean Group Estimator for the estimations of the exchange rate level and volatility.

To avoid over-parametrization and multicollinearty, yet test a wide range of different exchange rate determinants and control variables, we estimate 10 different model specifications with our core variables to which we add alternatingly controls from the different variable groups discussed above (see Table 1). As already highlighted, the choice of the cores variables is guided by our hypothesis of the central role of productive structure and financial characteristics in shaping the dynamics of exchange rate in African LLMICs. Global variables, which are common to all countries and hence would drop out in the AGM estimation, are included as interaction term. We chose openness, given its intuitive transmission channel, as increased openness is likely to increase the impact of global variables.

4. Empirical Results

4.1. Semi-Structured Interviews

Table 4 summarizes the responses of the foreign exchange experts with regards to the main exchange rate determinants in the six case study countries. Responses are divided into what respondents thought were the main foreign exchange flows, exchange rate fundamentals, and other potential determinants (e.g. political and speculative factors).

Table 4: Summary of Interview Results

Fundamentals/Countries	*Ghana*	*Kenya*	*Uganda*	*Zambia*	*Sierra Leone*	*Malawi*

Main Flows	• Remittances
	• Foreign Direct Investment
	• Portfolio investors
	• Oil revenues.
		• Dividend payments of foreign multinationals
		• Remittances
		• Tourism,
			• Portfolio investors
			• Cyclical and seasonal factors:
			  ○ Coffee seasons
			  ○ Dividends paid by multinationals, international banks and telecoms
				• Debt service	• Donor disbursements
					• Private financial resources	

Main Fundamentals	• Agent's interpretation of foreign exchange liquidity • Monetary policy decisions • Fiscal deficit • Current account balance • Inflation • Global market	• Current account • Corporate behaviour • Monetary policy stance • Fiscal considerations • Foreign currency debt	• Imports • Exports • Inflation • Fiscal deficit • Global factors • Interest rates • Market sentiment	• Imports of oil • Exports of copper • Seasonal factors (maise season)	• Imports • Exports (few mineral and commodities, in particular diamonds, gold, iron ore, cocoa, ginger and palm oil)	• Economic structure • Weather • Slippages in governances • Foreign assistance • Political cycles, • Fiscal factors • Policy reveals
Other Determinants	• Aggregate demand policies • Seasonal factors • Global tensions • Geopolitical factors	• Expectations • Sentiments for exchange rate movements	• Speculative forces • Political factors • Market development • Monetary policy stance. • News • Sentiments	• Political risks • Health risk	• Government debt • Political cycle	

With regards to the key exchange rate drivers or "fundamentals", all respondents pointed to the most significant balance of payments flows. For all countries traditional agricultural and mining exports continue to represent an important source of foreign exchange. Some also export oil (e.g. Ghana). To the exception of Kenya, most countries' exports remain concentrated in a few export commodities. Remittances and tourism were mentioned as an important source of foreign exchange in Kenya. Although foreign donor flows have decreased over recent years, they remain an important source of foreign exchange in Malawi and Sierra Leone. Interestingly, Foreign Direct Investment was not mentioned directly by the respondents, though some referred to corporate behaviour.

For Uganda and Ghana short-term foreign financial flows have assumed increased importance for exchange rate determination, and with it short-term interest rates and international market and US monetary conditions. Participants argued that the increased presence of foreign investors in local currency bonds had increased their impact on exchange rate movements. Moreover, it had increased the importance of local news and politics. With regards to the main reasons for foreign exchange demand, most countries remain highly import dependent, both with regards to food and fuel. In countries with a high presence of foreign companies (e.g. Zambia, Ghana, Uganda), profit repatriations are an important demand for foreign exchange according to our interviewees.

Other important drivers of the exchange rate mentioned in the case studies include the fiscal situation and government debt and borrowing (e.g. Ghana, Sierra Leone, Kenya, Uganda), external debt (e.g. Kenya, Zambia), inflation (Ghana, Sierra Leone, Uganda), monetary policy (e.g. Ghana), and the political cycle (e.g. Malawi, Sierra Leone, Uganda). Moreover, in most countries, there was a feeling that speculation and sentiment, both on behalf of domestic and foreign actors, could affect the exchange rate beyond the relevant flows and fundamentals, in particular during times of increased uncertainty.

Finally, all respondents thought that central banks remain key agents in African foreign exchange markets. Whereas in some countries, central bank interventions were mainly targeted at smoothing exchange rate volatility (e.g. Uganda and Ghana), or providing essential foreign exchange (e.g. Malawi and Sierra Leone), other central banks (in particular the central bank of Kenya) were seen to intervene more significantly in the foreign exchange market. According to one interviewee, these interventions have intensified over recent years as depreciation pressures on African currencies have increased.

4.2. Panel Regression Results

The results for the determinants of the exchange rate level and volatility using the AMG model are presented in Tables 5 and 6 respectively. Both models are well specified reflected in smaller Root Mean Squared errors (RMSE) and the chi-square statistic.

Table 5: Estimation of Exchange Rate Level using the AMG estimator

	Model1	*Model2*	*Model3*	*Model4*	*Model5*	*Model6*	*Model7*	*Model8*	*Model9*	*Model10*
GDP	-0.003	0.006	0.009	-0.001	0.002	-0.001	-0.001	0.002	-0.002	0.004
	(0.559)	(0.187)	(0.409)	(0.824)	(0.599)	(0.762)	(0.765)	(0.703)	(0.710)	(0.221)
Inflation	0.018**	0.018**	0.030**	0.019***	0.021***	0.018***	0.016***	0.016***	0.020***	0.017***
	(0.002)	(0.018)	(0.010)	(0.001)	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.004)
Yielddiff	-0.009***	-0.001	-0.016***	-0.009**	-0.010***	-0.008***	-0.007**	-0.006	-0.010***	-0.006***
	(0.003)	(0.900)	(0.005)	(0.014)	(0.001)	(0.000)	(0.032)	(0.104)	(0.000)	(0.052)
ToT	0.196***	0.188***	0.187**	0.125**	0.180***	0.178***	0.184***	0.182***	0.190***	-0.006
	(0.000)	(0.000)	(0.034)	(0.017)	(0.000)	(0.002)	(0.000)	(0.000)	(0.001)	(0.901)
ECI	0.455***	0.544***	0.519	0.381**	0.420***	0.549***	0.550***	0.586***	0.603***	0.576***
	(0.001)	(0.001)	(0.182)	(0.014)	(0.007)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
ECPI	-0.427***	-0.269*	0.065	-0.370***	-0.405***	-0.316**	-0.349***	-0.345***	-0.355***	-0.192***
	(0.004)	(0.069)	(0.763)	(0.003)	(0.000)	(0.012)	(0.000)	(0.000)	(0.003)	(0.002)
Portfolioinv	0.076	0.166	-0.004	0.009	-0.012	0.015	-0.009	0.001	0.003	0.067
	(0.589)	(0.141)	(0.930)	(0.685)	(0.662)	(0.733)	(0.634)	(0.956)	(0.891)	(0.620)
Otherinv	0.024*	0.009*	0.004	0.015***	0.013***	0.003	-0.004	-0.005	0.008	-0.029***
	(0.039)	(0.066)	(0.762)	(0.000)	(0.007)	(0.755)	(0.439)	(0.467)	(0.281)	0.004
Cab	-0.006*									
	(0.059)									
FDI		-0.011**								
		(0.046)								
Remmitance			0.047***							
			(0.000)							
ODA				-0.006***						
				(0.003)						
Debts					-0.001**					
					(0.040)					
Financialdev						0.994**				
						(0.012)				
Openness							0.006***			
							(0.000)			
VIX								0.325***		
								(0.000)		
Corruption									0.120**	
									(0.038)	

Climaticvul (lag1)										11.739***
										(0.000)
Time-Trend	-0.002	-0.004	0.051***	-0.004	-0.005	-0.001	-0.004	-0.005	-0.001	0.005
	(0.714)	(0.108)	(0.000)	(0.126)	(0.075)	(0.575)	(0.140)	(0.103)	(0.430)	(0.197)
_cons	4.837***	5.243***	3.256***	5.243***	5.591***	4.714***	5.193***	3.437***	5.384***	0.557
	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.349)
Number of obs	269	269	241	269	269	269	269	269	254	251
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	0.076	0.0754	0.0753	0.0764	0.0759	0.0756	0.0715	0.0710	0.0729	0.0624

Notes: p values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Several results are noteworthy. First, there is strong evidence that exchange rates in African LLMICs are driven by these countries' weak productive structures. Whereas an increase in the terms of trade and export concentration consistently depreciate the exchange rate across all estimations, an improvement in countries' export commodity prices appreciate it. Other structural factors matter too. Indeed, both positive foreign exchange inflows from the current account and FDI appreciate exchange rates in African LLMICs, whereas climatic vulnerability has a strong and negative (depreciating) impact on the exchange rate level. Second, with regards to the impact of financial and monetary factors, we find a strong negative effect of the interest rate differential on the exchange rate level, that is, an increase in the difference between the domestic and the US short-term interest rate appreciates the exchange rate. The impact of the private financial flows is less consistent. Whereas there are some signs that other investment (mainly banking flows) determines the exchange rate in some specifications the results are mixed and the sign changes. The interaction term between the VIX – as an indicator of international market conditions – and trade openness though is significant and positive. This means as international risk aversion increases, the currencies of African LLMICs experience significant depreciation pressures, which increase with the degree of trade openness. With regards to the macroeconomic controls, we find inflation to have a consistent depreciating effect on the exchange rate, whereas GDP seems to matter less.

Other balance of payments flows also affect the exchange rate. Specifically, whereas development aid seems to go hand in hand with an appreciating exchange rate, the relation with remittances is negative. For remittances, the causality goes potentially both ways as those flows act counter cyclically to stabilise weakening balance of payments. Finally, all political, and institutional factors show a significant, depreciating effect on exchange rates.

Table 6 presents the results for the determinants of exchange rate volatility using the AMG model.

Table 6: Estimation of Exchange Rate Volatility using the AMG Estimator

	Model1	*Model2*	*Model3*	*Model4*	*Model5*	*Model6*	*Model7*	*Model8*	*Model9*	*Model10*
GDP	-0.821*	-0.738	-1.038**	-0.631	-0.794*	-0.707*	-0.736	-0.755	-0.838	-0.560**
	(0.072)	(0.116)	(0.023)	(0.239)	(0.085)	(0.094)	(0.120)	(0.111)	(0.114)	(0.020)
Inflation	0.374**	0.293*	0.343	0.389	0.441**	0.371*	0.443*	0.470**	0.445**	0.344*
	(0.046)	(0.079)	(0.219)	(0.120)	(0.038)	(0.050)	(0.027)	(0.028)	(0.032)	(0.073)
Yielddiff	-0.062	-0.119	-0.222	-0.035	-0.153	-0.140	-0.178	-0.174	-0.165	-0.188
	(0.613)	(0.258)	(0.172)	(0.824)	(0.238)	(0.296)	(0.148)	(0.174)	(0.191)	(0.265)
ToT	-3.415*	-2.138	-2.135	2.010	-2.516	-0.832	-1.802	-1.809	-2.502	-2.396
	(0.050)	(0.154)	(0.362)	(0.394)	(0.162)	(0.574)	(0.152)	(0.131)	(0.268)	(0.247)
ECI	13.701*	16.227***	20.571***	17.947***	16.678***	16.497***	13.921***	14.313***	14.134*	14.343***
	(0.078)	(0.026)	(0.079)	(0.005)	(0.023)	(0.005)	(0.046)	(0.037)	(0.092)	(0.005)
ECPI	-5.735	-4.629	-4.452	-3.927	-5.394	-0.612	-4.208	-4.564	-5.890	2.799
	(0.236)	(0.325)	(0.483)	(0.535)	(0.295)	(0.915)	(0.385)	(0.345)	(0.234)	(0.479)
Portfolioinv	-2.232	0.211	-13.039	-2.492	-0.054	-1.777	2.123	2.147	7.250	-1.254
	(0.840)	(0.986)	(0.186)	(0.841)	(0.997)	(0.924)	(0.874)	(0.874)	(0.666)	(0.968)
Otherinv	-0.639*	-0.622*	-0.679	-0.669*	-0.603*	0.010	-0.789**	-0.786**	-0.497	1.099
	(0.071)	(0.083)	(0.184)	(0.059)	(0.092)	(0.992)	(0.022)	(0.022)	(0.196)	(0.373)
Cab	0.184**									
	(0.012)									
FDI		-0.079								
		(0.531)								
Remmitance			-0.315							
			(0.485)							
ODA				0.327**						
				(0.044)						
Debts					0.039**					
					(0.038)					
Financialdev						52.055**				
						(0.026)				
Openness							0.029			
							(0.320)			
VIX								1.700		
								(0.376)		
Corruptionl									5.451***	
									(0.000)	
Climaticvul (lag1)										106.031***
										(0.000)
Time-Trend	0.170	0.201	-0.054	0.208	0.208	0.156	0.227	0.233	0.226	0.019
	(0.284)	(0.205)	(0.767)	(0.352)	(0.194)	(0.295)	(0.170)	(0.173)	(0.189)	(0.911)
_cons	51.162*	40.037	42.094	15.674	43.733	3.296	34.413	26.286	51.250*	-44.232
	(0.044)	(0.102)	(0.203)	(0.649)	(0.099)	(0.915)	(0.158)	(0.396)	(0.037)	(0.140)
Number of obs	269	269	241	269	269	269	269	269	254	251
Prob > chi2	0.0529	0.0000	0.1629	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
RMSE	3.0955	3.0777	2.4925	2.3902	3.0844	2.7578	3.0228	2.9667	3.0032	2.4003

Notes: p values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We find that the productive factors, such as the export concentration index, the terms of trade, and climatic vulnerability have a strong influence on exchange rate volatility. Specifically, the coefficients on the export concentration index and the lag of climatic vulnerability are positive and significant at least at the 5% level. This suggests that the higher the country's reliance on few exports and with higher exposure to climatic failure, the larger the exchange rate volatility. The coefficient of the terms of trade is negative and significant at least at the 5% level, implying that an improvement in countries' terms of trade reduces exchange rate volatility. With regards to the financial and monetary factors, there is some evidence that an increase in other investments (banking flows) reduces exchange rate volatility.

The second major drivers of exchange rate volatility are the macroeconomic factors. High inflation leads to heightened exchange rate volatility and improvement in GDP growth reduces the exchange rate volatility. Other factors found to have significant influence on exchange rate volatility are: the external debt, financial development index and control of corruption index which are all found to have positive impacts on exchange rate volatility. Current account balance also has effect on the exchange rate though the result appears counterintuitive.

Finally, Tables 7 and 8 present the estimation results for the currency crash risk obtained from quantile panel regressions. In this paper we focus on the right tail of the distribution which represents medium-sized to strong depreciations of the exchange rates of African LLMICs[6]. Since we are interested in estimating the currency crash risk, which is reflected in strong depreciations, we focus on two different percent quantiles in the right tail of the distribution: the 75% percentile and the 90% percentile, which represent moderate to strong depreciations respectively.

Table 7 presents the estimated parameters for the 75th quantile and Table 8 presents the estimated results for the 90th quantile regression. In Appendix 4, we also present results for the 10th quantile (the left tail of the distribution) to compare drivers of strong depreciations to that of strong appreciations. As an estimation strategy, in addition to the eight core variables used in the AMG estimation, we also include the VIX in our core model. This is possible as quantile regression, unlike the AMG estimator, has the ability to estimate common observable variables.

[6] As indicated above, in our data an increase in the exchange rate reflects a depreciation of the domestic currency.

Table 7: Estimation of Crash Risk at 75TH Quantile

	Model1	*Model2*	*Model3*	*Model4*	*Model5*	*Model6*	*Model7*	*Model8*	*Model9*	*Model10*	*Model11*	*Model12*
Inflation	0.406*	0.366*	0.419**	0.368	0.410*	0.360**	0.365*	0.391	0.404*	0.244	0.391*	0.364***
	(0.073)	(0.082)	(0.033)	(0.115)	(0.068)	(0.035)	(0.080)	(0.103)	(0.091)	(0.106)	(0.054)	(0.007)
GDP	-0.323**	-0.298*	-0.301	-0.312*	-0.280*	-0.292*	0.315**	-0.353**	-0.306*	-0.358**	0.350***	0.382***
	(0.032)	(0.079)	(0.159)	(0.053)	(0.078)	(0.054)	(0.039)	(0.017)	(0.065)	(0.022)	(0.005)	(0.006)
VIX	0.302*	0.283	0.283*	0.280**	0.307**	0.267*	0.247	0.270*	0.224	0.349**	0.261	0.176
	(0.075)	(0.106)	(0.064)	(0.049)	(0.036)	(0.098)	(0.154)	(0.059)	(0.147)	(0.025)	(0.121)	(0.294)
Yielddiff	0.511***	0.546**	0.502**	0.533**	0.532**	0.552**	0.539**	0.599***	0.596**	0.680***	0.470*	0.463**
	(0.001)	(0.003)	(0.005)	(0.007)	(0.004)	(0.002)	(0.002)	(0.001)	(0.005)	(0.000)	(0.018)	(0.004)
ToT	0.736	1.266	1.756	1.144	1.167	1.173	0.957	-2.259	1.144	1.595	1.200	1.294
	(0.707)	(0.506)	(0.438)	(0.540)	(0.537)	(0.528)	(0.603)	(0.393)	(0.590)	(0.437)	(0.523)	(0.477)
ECI	5.377	7.482	12.866	6.987	12.922**	7.751	6.746	4.909	4.730	6.899	5.719	4.226
	(0.516)	(0.332)	(0.123)	(0.368)	(0.039)	(0.235)	(0.417)	(0.515)	(0.555)	(0.374)	(0.384)	(0.544)
ECPI	-0.030	-0.011	-0.014	-0.010	-0.027	-0.009	-0.011	-0.006	-0.022	0.001	0.142**	0.126**
	(0.497)	(0.812)	(0.789)	(0.846)	(0.525)	(0.824)	(0.809)	(0.888)	(0.636)	(0.987)	(0.041)	(0.047)
Portfolioinv	-1.782	-1.800	-1.838	-1.794	-1.891	-1.856	-1.797	-1.868	-1.790	-2.177	-1.760	-1.794
	(0.177)	(0.174)	(0.203)	(0.225)	(0.170)	(0.219)	(0.219)	(0.188)	(0.215)	(0.167)	(0.161)	(0.158)
Otherinv	-0.417	0.505**	0.567**	0.501**	0.748***	-0.524*	0.530**	-0.398	-0.482*	-0.520*	-0.465**	-0.487*
	(0.141)	(0.030)	(0.042)	(0.038)	(0.004)	(0.060)	(0.035)	(0.128)	(0.059)	(0.067)	(0.027)	(0.050)
Cab	-0.093											
	(0.512)											
FDI		0.022										
		(0.934)										
Remmitance			0.110									
			(0.779)									
Debts				0.004								
				(0.910)								
Reserves					0.107							
					(0.583)							
Financialdev						2.355						
						(0.913)						
Openness							-0.015					
							(0.710)					
Corruption								3.012				
								(0.204)				
Politicalsta									0.632			
									(0.705)			
Climaticvul										-33.580		
										(0.188)		
Commoditypri											-0.101**	
											(0.017)	
Oilprice												-0.071* *
												(0.016)
_cons	-3.215	-6.942	-9.753	-6.233	-7.455	-6.580	-3.422	11.737	-3.937	7.747	-5.951	-4.445
	(0.770)	(0.548)	(0.431)	(0.555)	(0.492)	(0.573)	(0.743)	(0.377)	(0.741)	(0.590)	(0.587)	(0.706)

Notes: p values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Estimation of Crash Risk at 90th Quantile

	Model1	*Model2*	*Model3*	*Model4*	*Model5*	*Model6*	*Model7*	*Model8*	*Model9*	*Model10*	*Model11*	*Model12*
Inflation	0.979**	0.931**	1.179***	0.959**	1.110***	0.798*	0.957**	1.223***	1.153***	0.809**	1.078***	1.077***
	(0.017)	(0.018)	(0.008)	(0.016)	(0.008)	(0.057)	(0.011)	(0.003)	(0.007)	(0.028)	(0.007)	(0.006)
GDP	-0.414	-0.370	-0.274	-0.150	-0.611	-0.212	-0.274	-0.516	-0.396	-0.244	-0.221	-0.206
	(0.446)	(0.478)	(0.656)	(0.777)	(0.294)	(0.701)	(0.582)	(0.333)	(0.473)	(0.607)	(0.669)	(0.687)
VIX	0.249	0.234	0.312	0.259	0.459	0.214	0.454	0.249	0.287	0.333	0.249	0.188
	(0.499)	(0.510)	(0.443)	(0.470)	(0.229)	(0.567)	(0.182)	(0.486)	(0.437)	(0.300)	(0.477)	(0.588)
Yielddiff	0.787**	0.827***	0.738**	0.812**	0.640*	0.945***	0.798***	0.746**	0.764**	0.933***	0.617*	0.645**
	(0.019)	(0.009)	(0.039)	(0.015)	(0.056)	(0.006)	(0.008)	(0.026)	(0.038)	(0.002)	(0.051)	(0.039)
ToT	-1.940	-0.574	1.781	-1.144	0.426	-0.537	-0.205	-1.253	0.690	0.217	-0.101	-0.611
	(0.764)	(0.926)	(0.825)	(0.857)	(0.952)	(0.935)	(0.974)	(0.846)	(0.916)	(0.970)	(0.987)	(0.922)
ECI	5.855	7.112	14.109	3.925	8.074	7.478	3.225	5.505	6.576	9.695	4.031	8.882
	(0.739)	(0.671)	(0.492)	(0.818)	(0.673)	(0.692)	(0.841)	(0.750)	(0.707)	(0.525)	(0.808)	(0.589)
ECPI	-0.162	-0.164	-0.148	-0.121	-0.146	-0.092	-0.119	-0.152	-0.137	-0.070	0.016	0.058
	(0.134)	(0.109)	(0.243)	(0.317)	(0.210)	(0.386)	(0.224)	(0.151)	(0.215)	(0.441)	(0.922)	(0.699)
Portfolioinv	-2.725**	-2.777**	-2.669*	-2.834**	-2.771**	-2.366*	-2.836**	-2.408*	-2.665**	-2.377**	-2.720**	-2.679**
	(0.037)	(0.026)	(0.050)	(0.025)	(0.036)	(0.073)	(0.018)	(0.053)	(0.040)	(0.039)	(0.028)	(0.029)
Otherinv	-0.591	-0.633	-0.634	-0.700	-0.636	-1.115	-0.632	-0.504	-0.642	-0.482	-0.617	-0.601
	(0.419)	(0.337)	(0.394)	(0.305)	(0.373)	(0.117)	(0.316)	(0.460)	(0.348)	(0.422)	(0.346)	(0.355)
Cab	-0.255											
	(0.385)											
FDI		0.735*										
		(0.075)										
Remmitance			-0.050									
			(0.962)									
Debts				0.038								
				(0.584)								
Reserves					0.020							
					(0.971)							
Financialdev						62.550						
						(0.110)						
Openness							-0.005					
							(0.967)					
Corruption								2.423				
								(0.714)				
Politicalsta									0.653			
									(0.856)			
Climaticvul										-80.037		
										(0.121)		
Commoditypri											-0.099	
											(0.287)	
Oilpric												-0.075
												(0.227)
_cons	20.285	13.221	0.002	11.558	7.076	2.101	6.581	19.022	5.802	43.991	10.506	8.103
	(0.537)	(0.675)	(1.000)	(0.719)	(0.845)	(0.951)	(0.828)	(0.581)	(0.864)	(0.231)	(0.746)	(0.800)

Notes: p values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

One can observe the crucial role of the inflation rate and the interest rate differential for medium to strong exchange rate depreciations. Both variables are strongly significant for both quantiles and the coefficient increases in the higher quantile. This result reflects the fact that in most African economies, when there is a strong rise in domestic interest rates, this indicates a worsening of domestic macroeconomic conditions which can discourage capital inflows. At the same time, a high interest rate differential can attract jittery, yield seeking flows (the carry trade), which are quick to pull out when conditions change.

Indeed, whereas productive factors seem to matter less for substantial depreciations, other financial factors play a significant role in our estimations. In particular, for medium sized depreciations our indicator of international risk aversion, the VIX, is significantly positive across several specification. Moreover, short-term financial flows have a significant and

negative impact on strong exchange rate depreciations in our sample; whereas other investment (banking flows) seem to matter more for medium-sized depreciations, portfolio flows have a strongly negative impact on episodes of very large exchange rate depreciations. This indicates that the crash risk of African LLMICs currencies is significantly related to withdrawals of short-term foreign financial flows, in particular portfolio flows.

With regards to our macroeconomic and institutional control variables, we find that an increase in GDP lowers the risk of medium-sized depreciations, but has no impact on the 90th percentile. Similarly, whereas an increase in commodity prices and oil prices lowers the risk of medium-sized depreciations, they seem to matter less for very large exchange rate adjustments at the 90th percentile. Interestingly, whereas African LLMICs productive structure seems to matter little for the risk of large exchange rate depreciations, they seem to have some impact on episodes of strong appreciations. As can be seen in Table A4, for the 10th quantile export concentration has a significant positive effect on exchange rate changes. Similarly, institutional factors and political stability, as well as climatic vulnerability, seem to matter more for the left tail of the distribution.

In sum, our estimations show the crucial importance of considering Africa' distinct productive and monetary/financial structure for exchange rate determination. Whereas its concentrated and commodity-based export structure is important for the level and volatility of the exchange rate, monetary and financial factors matter particularly for the crash risk. The models are well specified as reflected in the adjusted R squared greater than 0.7 across all the quantiles.

4.3 Robustness Checks

We conducted the robustness check on the exchange rate level to validate the estimation results in the previous section using panel DOLS and panel fixed effect (FE) in first difference. Both panel DOLS and FE estimated in first difference have the ability to deal with cross-sectional dependence problem. Tables 10 and 11 report the results for the DOLS and FE estimation respectively.

Table 10: Panel DOLS on the Exchange Rate Level

	Model1	*Model2*	*Model3*	*Model4*	*Model5*	*Model6*	*Model7*	*Model8*	*Model9*
GDP	-0.006	-0.006	-0.030***	-0.010	-0.010*	-0.007	-0.008	-0.012**	0.001
	(0.208)	(0.248)	(0.006)	(0.379)	(0.069)	(0.181)	(0.180)	(0.031)	(0.926)
Inflation	0.025***	0.025***	0.022**	0.025*	0.027***	0.025***	0.025***	0.029***	0.014**
	(0.000)	(0.000)	(0.004)	(0.036)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Yielddiff	0.005*	0.005*	0.017***	0.015	0.007**	0.004	-0.001	0.005	0.008**
	(0.099)	(0.087)	(0.005)	(0.105)	(0.031)	(0.167)	(0.800)	(0.191)	(0.017)
ToT	0.495***	0.505***	0.460***	-0.164	0.435***	0.490***	0.451***	0.711***	0.901***
	(0.000)	(0.000)	(0.000)	(0.244)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ECI	0.499***	0.653***	0.320	1.316***	0.549***	0.587***	0.436*	-0.312*	0.270
	(0.001)	(0.000)	(0.430)	(0.005)	(0.004)	(0.000)	(0.012)	(0.067)	(0.122)
ECPI	0.006***	0.005**	0.006*	-0.008*	0.005**	0.006***	0.006**	0.004*	0.003
	(0.000)	(0.004)	(0.083)	(0.034)	(0.010)	(0.001)	(0.005)	(0.048)	(0.174)
Portfolioinv	-0.024*	-0.023*	0.034**	0.050*	-0.012	-0.031**	-0.041***	-0.017	0.017
	(0.056)	(0.072)	(0.044)	(0.053)	(0.371)	(0.019)	(0.003)	(0.224)	(0.216)
Otherinv	-0.034***	-0.034***	-0.013	0.003	-0.042***	-0.036***	-0.044***	-0.034***	-0.017**
	(0.000)	(0.000)	(0.225)	(0.804)	(0.000)	(0.000)	(0.000)	(0.000)	(0.013)
Cab	-0.002								
	(0.469)								
ODA		-0.015***							
		(0.000)							
Remmitance			0.102***						
			(0.000)						
Reserves				-0.025*					
				(0.074)					
Financialdev					6.792***				
					(0.000)				
Openness						0.001			
						(0.221)			
Corruption							0.106		
							(0.145)		
Politicalsta								-0.071**	
								(0.034)	
Climaticvul									-9.304***
									(0.000)

Notes: p values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11: FE (estimated in first difference) on the Exchange Rate Level

	Model1	*Model2*	*Model3*	*Model4*	*Model5*	*Model 6*	*Model7*	*Model8*	*Model9*	*Model10*	*Model11*	*Model12*
D.GDP	-0.679	-0.602	-1.130	-0.478	-0.612	-0.598	-0.499	-0.211	-0.088	-0.588	-0.664	-0.162
	(0.222)	(0.243)	(0.162)	(0.294)	(0.251)	(0.259)	(0.397)	(0.748)	(0.895)	(0.266)	(0.231)	(0.679)
D.Inflation	1.836**	1.752**	1.403**	1.482**	1.928**	1.847**	1.300	2.010**	1.930**	1.832**	2.055**	2.183***
	(0.020)	(0.023)	(0.046)	(0.036)	(0.012)	(0.020)	(0.112)	(0.033)	(0.030)	(0.019)	(0.011)	(0.008)
D.Yielddiff	3.956*	3.898*	4.655*	4.171*	3.701*	3.866*	3.517*	4.983*	4.865*	3.880*	4.131*	3.311
	(0.075)	(0.090)	(0.066)	(0.078)	(0.099)	(0.083)	(0.071)	(0.076)	(0.077)	(0.088)	(0.082)	(0.119)
D.ToT	-22.588	-33.151	-11.524	-4.462	-17.975	-14.572	-9.955	-37.572	-39.568	-14.664	-20.435	-32.870
	(0.560)	(0.471)	(0.765)	(0.873)	(0.664)	(0.653)	(0.755)	(0.452)	(0.425)	(0.652)	(0.528)	(0.395)
D.ECI	182.83*	183.19*	214.91*	193.87*	201.4*5	178.80*	178.64*	200.42*	207.95*	177.62*	179.49*	178.71 *
	(0.073)	(0.073)	(0.062)	(0.075)	(0.070)	(0.076)	(0.083)	(0.092)	(0.088)	(0.073)	(0.073)	(0.051)
D.ECPI	-1.36**	-1.25***	-1.60***	-1.32**	-1.35**	-1.37***	-1.69**	-1.48**	-1.53**	-1.39***	1.319***	0.121
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)	(0.631)
D. Portfolioinv	-3.876	-4.253*	-3.195	-3.969	-2.943	-3.820	-3.543	-3.509	-3.434	-3.762	-3.012	-3.906
	(0.172)	(0.096)	(0.327)	(0.175)	(0.293)	(0.180)	(0.252)	(0.213)	(0.229)	(0.176)	(0.276)	(0.221)
D.otherinv	1.727	1.519	0.621	1.747	2.216	1.858	1.765	2.049	2.149	1.899	1.571	2.521
	(0.484)	(0.491)	(0.780)	(0.501)	(0.368)	(0.456)	(0.477)	(0.408)	(0.407)	(0.438)	(0.510)	(0.364)
D.Cab	0.647											
	(0.437)											
D.FDI		-3.184										
		(0.267)										
D.Remmitance			16.063**									
			(0.009)									
D.ODA				5.278								
				(0.226)								
D.Reserves					4.853							
					(0.110)							
D. Financialdev						-84.055						
						(0.570)						
D.Openness							2.629					
							(0.221)					
D. Corruptionl								-37.524				
								(0.387)				
D. Politicalsta									-27.836			
									(0.214)			
D. Climaticvu										80.316		
										(0.888)		
D.VIX											-2.080*	
											(0.081)	
D.Oilprice												-0.842**
												(0.009)
_cons	47.484*	47.560*	50.003*	48.336*	48.470*	47.273*	45.351*	51.486*	51.532*	47.307*	45.820*	47.145*
	(0.029)	(0.030)	(0.035)	(0.032)	(0.029)	(0.030)	(0.023)	(0.037)	(0.036)	(0.028)	(0.029)	(0.030)

Notes: p values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Generally, the outcomes for the DOLS and FE (estimated in first difference) are similar to those obtained from our AMG estimations, confirming the importance of productive structures and financial factors on the level of the exchange rate. Key productive and financial factors that drive the exchange rates are: terms of trade (depreciating), country's export commodity price index (appreciating), the export concentration index (depreciating), the yield differential (depreciating) and other investments (appreciating). Other factors which play a significant role are: inflation (depreciating), overseas development aid (appreciating) and remittances (depreciating), and the financial development index (depreciating).

5. Conclusions

Economic transformations in African LLMICs, specifically the liberalization in foreign exchange markets and capital accounts and the move to more floating exchange rates, have increased the importance of investigating the determinants of the nominal exchange rate in those economies. Existing studies focus either on real exchange rate determination or single case studies. So far there is no empirical work which estimates the determinants of the nominal exchange rate across a significant panel of LLMICs. This paper fills this gap. It combines semi-structured interviews in selected African LLMICs, with macro-panel estimations in 15 countries to investigate the determinants of nominal exchange rates. Conceptually, it was motivated by the observation that rather than universal fundamentals, exchange rates are driven by country and time specific factors, mediated by the operations of key actors in the foreign exchange market. In particular, it has argued that exchange rate determination might differ in African LLMICs given their specific productive and export structure, concentrated in a few agricultural and mining commodities, and the specific way they are integrated into international financial markets through the preponderance of yield seeking – potentially destabilising – financial flows in the context of thin financial markets and weak currencies.

The interview results pointed to the key role of balance of payments flows (both from the current account and short-term financial flows), external debt and government borrowing, inflation, monetary policy, and interest rate decisions (both domestically and abroad), and political factors as drivers of the exchange rate. The econometric results confirmed many of these exchange rate drivers. They showed the key role of African LLMICs productive structure, approximated by their concentration of exports, terms of trade, prices of their main export commodities and exposure to climatic vulnerability, for the level and volatility of the exchange rate. Whereas the impact of short-term financial flows was mixed, the yield differential with the US and international market conditions (the VIX) were also significant in explaining the exchange rate level. Financial factors gained particular importance for explaining the crash risk, that is medium-sized to large exchange rate depreciations. Whereas indicators of productive structure mattered little for these large exchange rate adjustments, financial factors – including the interest rate differential, international market conditions, and short-term financial flows - had a strong and significant impact. Moreover, results confirmed the important role of inflation, GDP and institutional factors such as trade openness and and

political stability on the exchange rate. These results matter as potentially more African LLMICs move towards more floating exchange rates and capital account liberalization and show the potential complications Africa's distinct integration in the global economy, both on the productive and the financial side, might bring for the implementation of such regime and more market-determined exchange rates.

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Appendix 1: Summary of Main Exchange Rate Determinants in the Literature

Table A1a. Developing and Emerging Economies

	Variable	*Effect*
Level/Return	Fiscal Factors	Appreciate
	Terms of Trade	Appreciate
	Openness	Depreciate
	Productivity	Appreciate
	Interest Rates	Appreciate
	Capital Flow and Stock Variables	Appreciate/Depreciate
Volatility	Output	-
	Interest Rates	-
	Financial Factors	-
Crash Risk	Economic Growth	-
	Domestic Credit Growth	-
	Foreign Interest Rate	-
	FDI to Debt ratio	-

Table A1b. African LICs and LMICs

	Variable	*Effect*
Level/Return	Fiscal Factors	Appreciate
	Terms of Trade	Appreciate
	Openness	Depreciate
	Interest Rates	Appreciate
	Capital Flow and Stock Variables	Appreciate/Depreciate
Volatility	Commodities	-
	Interest Rates	-
	Capital Flow and Stock Variables	-
Crash Risk	Inflation	-
	M2 Multiplier	-
	Bank Deposits	-
	Exports	-
	Terms of Trade	-
	Exchange Rate Deviation from Trend	-
	Lending to Deposit Ratio	-

Appendix 2: Official Exchange Rate Regime, IMF Classification, Monetary Policy Framework, and Capital Account Openness

Country	*Official Exchange Rate Regime*	*Exchange Rate Classification by the IMF*	*Monetary Policy Framework*	*Capital Account Openness (1=fully liberalised)*
Egypt	Floating	Stabilised arrangement	Flexible money-targeting framework	0.86
Ethiopia	Managed Floating	Crawl-like arrangement	Price and exchange rate stability. Monetary aggregate target	0
Gambia	Free-Floating	Other managed arrangement	Monetary aggregate target	No data
Ghana	Floating	Floating	Inflation-targeting framework	0.64
Kenya	Free-Floating	Other managed arrangement	Transition from targeting monetary aggregates toward an inflation-targeting framework.	0.57
Madagascar	Free-Floating	Floating	Monetary aggregate target	0.07
Malawi	Floating	Stabilised arrangement	Monetary aggregate target	0.14
Mauritania	Floating	Crawl-like arrangement	Multiple targets: price and financial system stability	0.27
Mozambique	Floating	Floating	The monetary policy regime is based on the interest rate as an operating target.	0
Nigeria	Floating	Stabilised arrangement	Monetary aggregate target	0.86

Rwanda	Floating	Crawl-like arrangement	Monetary aggregate target	1
Sierra Leone	Floating	Other managed arrangement	Monetary aggregate target	0.21
Tanzania	Free-Floating	Crawl-like arrangement	Monetary aggregate target	0.07
Uganda	Free-Floating	Floating	Inflation-targeting framework	1
Zambia	Floating	Floating	Policy rate as a key policy instrument to signal the monetary policy stance	1

Source: AREAER International Monetary Fund; IMF Capital Account Openness. The capital account index was published in April 2016 (with information from 1996 to 2013).

Notes: According to the IMF a free-floating regime is one where foreign exchange interventions only occurs exceptionally to address disorderly market conditions. Authorities need to provide information that confirms that such interventions were limited to "at most six instances in the previous six months, each lasting no more than three business days". In case that such information is not available the IMF classifies the exchange rate as floating.

Appendix 3: Pre-Estimation Tests

Table A3a: VIF

Variable	*VIF*	*1/VIF*
Commodityprice	74.21	0.013475
Oilprice	57.89	0.017274
Openness	3.96	0.252361
ECPI	3.94	0.254104
FDI	3.86	0.259376
Cab	3.79	0.263659
Politicalsta	3.28	0.304828
Climaticvul	3.14	0.318058
Financialdev	3.00	0.333013
Debts	2.78	0.359945
ODA	2.57	0.389081
Otherinv	2.21	0.452095
Corruption	2.19	0.456220
Yielddiff	2.07	0.482327
Inflation	1.85	0.541877
ToT	1.77	0.564685
Ustbill	1.73	0.578370
Reserves	1.71	0.584110
ECI	1.64	0.608947

Remmitance	1.54	0.649906
Portfolioinv	1.53	0.653096
VIX	1.25	0.800497
GDP	1.18	0.847108
Mean VIF	7.96	

Table A3b: Cross-sectional Dependence Test for the Foreign Exchange Level Model

Pesaran (2003) CD test

	CD	*p-value*	*corr*	*abs(corr)*
Exchange rate index (log)	49.74	0.000	0.845	0.845
Residual	13.98	0.000	0.301	0.348

Pesaran (2004/2015) CD

	CD-test	*p-value average*	*joint T*	*Mean ρ*	*mean abs(ρ)*
Exchange rate index (log)	49.741	0.000	15.00	0.85	0.85
Residual	17.903	0.000	14.07	0.25	0.34

Table A3c: Cross-sectional Dependence Test for the Foreign Exchange Volatility Model

Pesaran (2003) CD test

	CD	*p-value*	*corr*	*abs(corr)*
Volatility	9.79	0.000	0.166	0.255
Residual	5.23	0.000	0.112	0.255

Pesaran (2004/2015) CD

	CD-test	*p-value average*	*joint T*	*Mean ρ*	*mean abs(ρ)*
Volatility	9.789	0.000	15.00	0.17	0.25
Residual	2.708	0.007	14.07	0.04	0.15

Table A3d: Panel Unit Root Test Using both First and Second-Generation Unit Root Tests

Variable	*Level*			*First Difference*
	Im-Pesaran-Shin IPS t-bar	fisher	pescadf	pescadf
FX (log)	-4.9491***	-18.8455 ***	-1.980	-1.964
	(0.000)	(0.0000)	(0.134)	(0.149)
FX Volatility	-3.7455***	-12.2716***	-1.918	-2.034*
	(0.000)	(0.000)	(0.199)	(0.091)
GDP Growth	-4.3267***	-15.5416***	-3.055***	
	(0.000)	(0.0000)	(0.000)	
Inflation	-4.3912***	-15.6116***	-2.922***	
	(0.000)	(0.0000)		
			(0.000)	
Yield Differential	-4.0168***	-14.0083***	-4.000 ***	
	(0.000)	(0.0000)	(0.000)	
Term of Trade (Log)	-3.7939***	-12.9015***	-6.032***	
	(0.000)	(0.0000)	(0.000)	
Portfolio inv	-13.2616***	-24.8434***	-3.410***	
	(0.000)	(0.0000)	(0.000)	
Other inv	-4.1029***	-14.3619 ***	-3.789***	
	(0.000)	(0.0000)	(0.000)	
ECPI (log)		-12.7143	-2.743	
		(0.0000)	(0.000)	
ECI				
Current account balance	-3.6697***	-12.1471***	-1.841	-2.004
	(0.000)	(0.0000)	(0.302	(0.113)
FDI	-3.5465***	-11.3442***	-2.090	
	(0.000)	(0.0000)	(0.057)	
External Debts	-3.0605***	-8.8366***	-1.827	-2.525***
	(0.000)	(0.0000)	(0.325)	(0.000)
ODA	-4.5406***	-16.7644***	-1.913	-2.105
	(0.000)	(0.0000)	(0.205)	(0.050)
Remittances	-3.9989***	-13.8409***	-1.653	
	(0.000)	(0.0000)	(0.049)	
Openness	-2.6729***	-6.5859 ***	-2.937***	
	(0.0000)	(0.0000)	(0.000)	

Notes: p values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 4: Quantile Regressions for the Left-Tail (Appreciations)

Table A4: Estimation of Crash Risk at 10th Quantile

	Model1	*Model2*	*Model3*	*Model4*	*Model5*	*Model6*	*Model7*	*Model8*	*Model9*	*Model10*	*Model11*	*Model12*
Inflation	0.287*	0.259	0.360**	0.336**	0.350**	0.178	0.277*	0.304*	0.227	-0.011	0.283*	0.259
	(0.074)	(0.156)	(0.019)	(0.027)	(0.041)	(0.232)	(0.074)	(0.063)	(0.170)	(0.948)	(0.061)	(0.125)
GDP	0.061	0.005	-0.092	-0.011	-0.183	-0.003	0.088	-0.055	-0.054	-0.047	0.060	0.092
	(0.774)	(0.984)	(0.668)	(0.957)	(0.443)	(0.989)	(0.670)	(0.796)	(0.800)	(0.829)	(0.763)	(0.680)
VIX	0.063	0.001	0.001	0.037	-0.056	-0.091	-0.080	-0.099	0.095	-0.119	0.046	0.003
	(0.660)	(0.997)	(0.996)	(0.786)	(0.722)	(0.498)	(0.569)	(0.489)	(0.508)	(0.420)	(0.731)	(0.984)
Yielddiff	0.286**	0.284*	0.175	0.271**	0.241*	0.359***	0.282**	0.127	0.345**	0.362***	0.141	0.189
	(0.030)	(0.053)	(0.162)	(0.032)	(0.079)	(0.004)	(0.024)	(0.344)	(0.016)	(0.009)	(0.241)	(0.164)
ToT	-0.847	-0.480	4.008	0.108	2.460	-1.473	0.848	-1.807	-1.496	1.305	1.205	0.688
	(0.738)	(0.868)	(0.156)	(0.964)	(0.397)	(0.530)	(0.741)	(0.484)	(0.559)	(0.620)	(0.622)	(0.801)
ECI	4.927	10.087	17.947**	6.074	14.487*	12.877*	10.102	11.254	13.610**	8.724	11.049*	9.018
	(0.474)	(0.196)	(0.013)	(0.350)	(0.065)	(0.057)	(0.129)	(0.104)	(0.047)	(0.215)	(0.082)	(0.208)
ECPI	-0.032	-0.004	-0.053	-0.041	-0.014	-0.024	-0.017	0.047	-0.012	-0.029	0.084	0.057
	(0.454)	(0.926)	(0.236)	(0.368)	(0.761)	(0.530)	(0.665)	(0.269)	(0.772)	(0.483)	(0.182)	(0.377)
Portfolioinv	-0.020	-0.048	-0.102	0.011	0.037	-0.358	0.011	-0.095	-0.184	0.140	-0.167	-0.097
	(0.969)	(0.933)	(0.830)	(0.981)	(0.946)	(0.447)	(0.983)	(0.848)	(0.715)	(0.790)	(0.724)	(0.855)
Otherinv	-0.217	-0.185	-0.436*	-0.238	-0.233	-0.104	-0.214	-0.051	-0.422	-0.097	-0.183	-0.128
	(0.449)	(0.546)	(0.094)	(0.359)	(0.426)	(0.681)	(0.409)	(0.851)	(0.115)	(0.724)	(0.465)	(0.650)
Cab	0.026											
	(0.822)											
FDI		-0.127										
		(0.505)										
Remmitance			0.184									
			(0.612)									
Debts				-0.007								
				(0.786)								
Reserves					-0.134							
					(0.556)							
Financialdev						21.826						
						(0.118)						
Openness							-0.088*					
							(0.055)					
Corruption								-1.287				
								(0.627)				
Politicalsta									-3.042**			
									(0.031)			
Climaticvul										-43.971*		
										(0.065)		
Commoditypri											-0.062*	
											(0.080)	
Oilpric												-0.041
												(0.131)
_cons	-4.298	-6.627	-24.420	-7.106	-16.967	-2.956	-6.373	-3.892	-6.895	14.540	-15.235	-11.385
	(0.738)	(0.651)	(0.082)	(0.561)	(0.255)	(0.808)	(0.611)	(0.778)	(0.602)	(0.389)	(0.220)	(0.413)

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