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ABSTRACT

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Over the past 30 years (1990-2019), African economies have experienced remarkable improvements in macroeconomic conditions, characterized by higher and more stable real per-capita growth rates, and lower and more stable inflation. This paper documents the persistent decline in macroeconomic volatility at the aggregate and sectoral levels, and seeks to provide explanations. Sectoral analysis shows a particularly strong reduction of growth volatility in agriculture, and, to a lesser extent, in services. Analysis of a broad range of explanatory factors yields that only a small fraction of the moderation can be explained by structural change, and changes in major structural characteristics such as institutions, trade intensity and diversification, natural resource dependence, or conflict incidence. Evidence suggests that changes in the external environment, improved macroeconomic policy frameworks, and 'softer' structural improvements such as the deepening of the financial sector and increases in human capital, were important towards reducing volatility on the continent.

Keywords: macoeconomic stability and resilience, growth, inflation, volatility, structural change, macroeconomic policy
JEL classification: O11; E30; E60

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1 Introduction

In both academic literature and policy discourse, Africa has long been conceived as a continent of unstable macroeconomic conditions, where a majority of countries suffer from volatile growth rates, high and volatile inflation, and a multitude of other macroeconomic problems including fiscal spending, debt levels, and exchange rate management. But, as documented by Calderon and Boreux (2016), Rodrik (2018) and others, starting around 1995 many African economies have experienced real growth rates above 5%, well above those of the 1970s and '80s. Whereas real growth has slowed a bit again to around 3-4% from 2012 onwards, the past 30 years from around 1990 show a much more persistent and pronounced process of macroeconomic moderation in Africa, where real growth volatility was cut in half, and inflation volatility is less than a third of its value at the beginning of the period.

This paper investigates macroeconomic volatility in Africa over the last 30 pre-COVID years (1990-2019). It documents the decline of macroeconomic volatility at the aggregate and sector levels, and then seeks to draw links to changes in production, external conditions, macroeconomic policy, and structural characteristics of African economies. Using a variety of empirical methods spanning time series analysis, sectoral decompositions of volatility, panel-regressions to assess changes in policy, and machine learning models to assess a wide variety of structural characteristics, it establishes two main findings. First, only a small fraction of the stark decline in macroeconomic volatility in Africa can be explained by structural change (i.e. the rise of the service sector), other changes in the structure of production and trade, or changes in conflict incidence and political institutions. Secondly, the evidence suggests that changes in the external environment, improved internal policy frameworks, and 'softer' structural improvements such as the deepening of the financial sector, and increases in human capital, were important in reducing volatility on the continent.

The paper contributes to a broad literature on macroeconomic volatility in developing countries such as Ramey and Ramey (1995), Rodrik (1999), Easterly et al. (2001), Acemoglu et al. (2003), Auffret (2003), Koren and Tenreyro (2007), Loayza et al. (2007), Malik and Temple (2009), Papageorgiou and Spatafora (2012). It differs from most of this literature by adopting a regional focus on Africa, and endeavouring a comprehensive examination of developments in that region - through analysis of many different factors via multiple empirical approaches. Declining volatility in macroeconomic aggregates, sometimes termed the 'Great Moderation', has also been studied in

economic literature, predominantly in the US context such as Blanchard and Simon (2001), but also in the global context such as Horan (2006), and emerging economy context such as Schmidt-Hebbel (2009), who also notes that moderation occurred with a lag in developing countries. The literature has not reached a consensus on the causes of moderation. This paper provides evidence that the causes of moderation in Africa are different from those studied in the great moderation literature.

The paper is structured as follows: Section 2 characterizes broad trends in the volatility of real per-capita growth rates and CPI inflation in Africa and the world, and develops the stylized facts that motivate the analysis. Section 3 goes down to the sector level and analyzes growth volatility in Africa mainly from the production side, seeking to quantify the contribution of different sectors to the moderation, and the role of structural change. Having found a limited role for structural change, section 4 proceeds to examine changes in the external environment faced by African economies, the domestic financial sector, and in macroeconomic policies, in their relationship to African moderation. Section 5 complements this analysis by assessing a broad range of (semi-)structural characteristics of African economies. Section 6 summarizes the findings and concludes.

2 Aggregate Relationships and Trends

The decline in macroeconomic volatility in the median African country since 1990 has been profound. Figure 1 shows 10-year rolling medians and median absolute deviations (MADs)[1] of real per capita growth and inflation in Africa and the rest of the world (ROW), using data[2] from 1980 where available[3], aggregated across countries for each year using the median. While the whole world has experienced a sizeable macroeconomic moderation in terms of lower inflation and lower volatility of real growth and inflation, this moderation has been particularly strong in Africa, which experienced stronger declines in growth and inflation volatility, alongside higher growth rates. The bulk of the African transformation has taken place between 1995 and 2012, with median per capita growth almost zero in 1986-95, rising to 2.8% in 2003-12. At the same time, the MAD of growth fell from 2.2% to 1.3%, median inflation fell from ∼8% to ∼5%, and the MAD of inflation fell from 3.8%

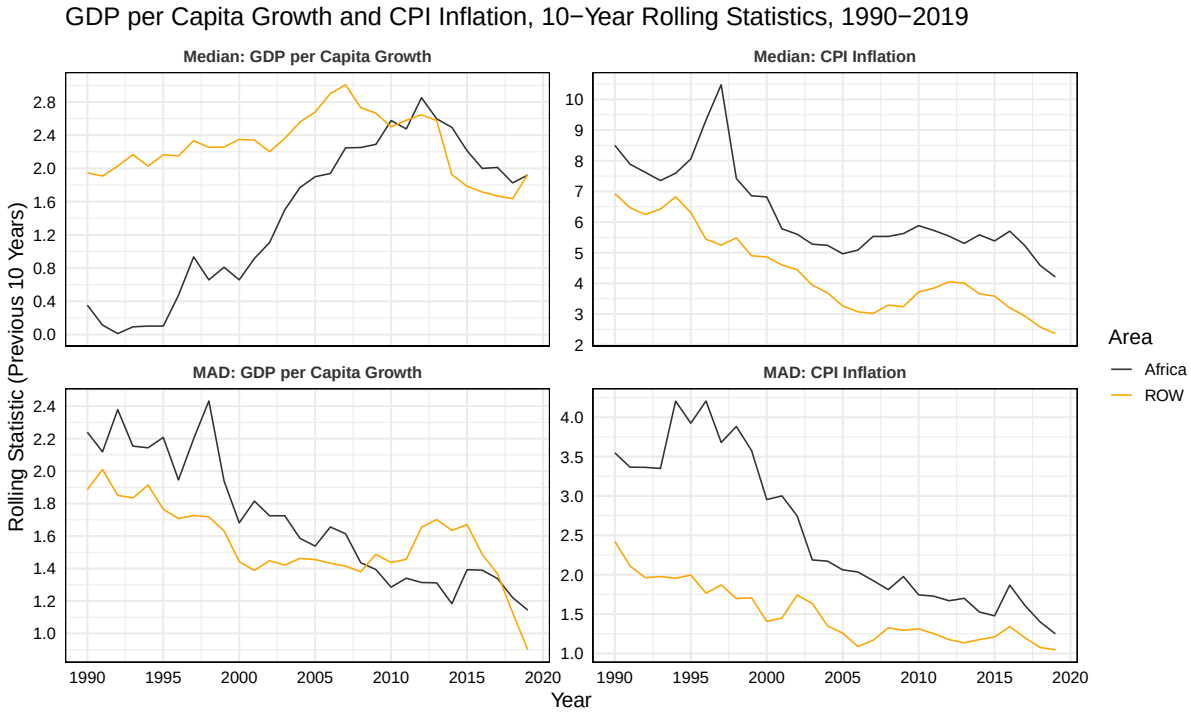
[1] The measurement of macroeconomic volatility, and its performance over time, is of great importance in the scope of this paper. A broad body of literature, such as Ramey and Ramey (1995), has used the standard deviation of the GDP per Capita growth rate as a proxy for macroeconomic volatility. In Africa, the low quality of macroeconomic data, and the troubled history of some countries, invites the use of robust volatility measures like the MAD or IQR. Appendix Section 1 provides a broader frequency domain analysis, which includes a thorough discussion and justification of the growth-based volatility measures used in this paper.

[2] Most empirical studies rely on the Penn World Table (PWT) or World Development Indicators (WDI), which provide long historical data series, but for Africa rely more heavily on data interpolation methods. This research considers data from the IMF World Economic Outlook (WEO), supplemented by data from the World Bank for sectoral disaggregation and robustness checks. WEO data is collected by IMF country economists from local sources, but only available from 1990 for most African countries. Appendix Figure A6 shows the logarithm of GDP per capita according to the IMF World Economic Outlook (WEO) for 52 African economies from 1990-2019. GDP has been subject to large shocks in several countries, such as the 1994 Rwandan Genocide, which can result in extreme values of growth rates.

[3] Countries with less than 15 10-year rolling intervals (i.e. <25 consecutive observations) for either growth or inflation are not considered for Figure 1. In Africa this comprises Liberia, Somalia, South Sudan, and Zimbabwe.

to 1.8%. After 2003-12, per capita growth in Africa slowed down to 2% in the most recent decade (in line with ROW) alongside further improvements in inflation and volatility, with median inflation coming as low as 4.2% and the MAD dropping to 1.25% in the 2010-2019 period. These trends are robust to weighting countries by GDP or population, as shown in Appendix Figure A7.

Figure 1: Volatility Over Time



Data Source: IMF World Economic Outlook, October 2021

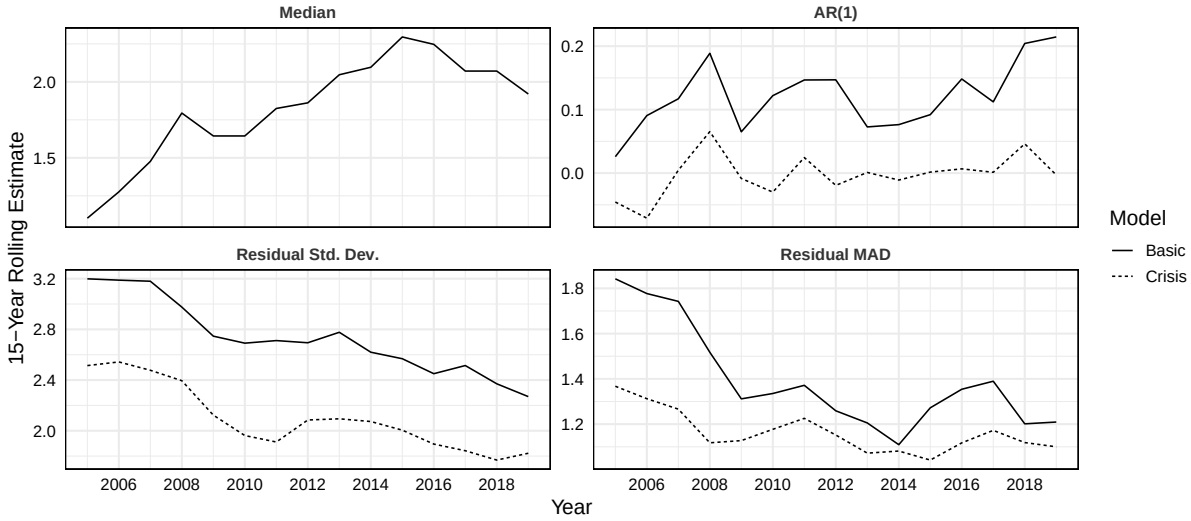
It is important to point out at this stage that what has happened in Africa in the past 20-25 years is more than a mirror image of the global great moderation. Figures A8 and A9 in the appendix show versions of Figure 1 with alternative World Bank data and with year-medians subtracted from the rolling statistics, emphasizing the strong development of Africa both in terms of real growth and greater stability in the past 20-25 years, holding fixed global factors.

Documenting the decline in US output volatility, Blanchard and Simon (2001) run a rolling autoregression of the GDP growth rate over a 20-quarter window to gauge whether the decrease in volatility is due to a decrease in the persistence of shocks, as measured by the AR1 coefficient. They also add a crisis dummy (NBER recessions) to control for large shocks. Blanchard and Simon (2001) find that the US decline in output volatility is due to declines in the magnitude of shocks, reflected in the volatility of the residual, and that this holds also when controlling for NBER recessions.

Figure 2 shows the results of a similar analysis conducted for Africa, where I have estimated autoregressions at the country-level using a 15-year rolling window, and aggregated the results using the median. The crisis definition is adapted from the IMF country risk assessment for LICs (Syed

et al., 2017; IMF, 2021), a crisis having occurred if the 2-year average level of real output per capita post-shock (t and t+1) falls below the pre-shock 3-year average level, and output per capita growth is negative in the year of the shock (t) (see Figure A10).

Figure 2: AR1 Analysis of GDP per Capita Growth in Africa a la Blanchard and Simon (2001)



Data Source: IMF World Economic Outlook, October 2021

Figure 2 indicates that more or less the same conclusions hold for Africa. The persistence of real output growth even appears to have increased slightly[4], thus the decline in volatility is largely associated with factors captured in the residual of the model.

To shed some light on heterogeneity within the continent, Table 1 compares changes for countries at different income levels, computing statistics over the 1990-2004 and 2005-2019 periods. In Africa, LICs experienced the largest growth acceleration from 1.1% in 1990-04 to 2.25% in 2005-19, alongside a remarkable stabilization of growth from a MAD of 2.43 down to 1.12, and a similar stabilization of inflation from a MAD of 4.34 down to 1.95. A similar but slightly weaker development was experienced by LMICs in both Africa and ROW. The aggregate statistics for Africa and ROW confirm the results of Figure 1, that in terms of real growth and volatility, Africa performed very similar to ROW in the 2005-19 period. The only real difference remains the higher median level of inflation at 5.2% in Africa, compared to 2.8% in ROW.

[4]This increase in persistence is even more visible in World Bank data, see Figure A11 in the appendix.

Table 1: Volatility Over Time

			Per Capita Growth			Inflation		
Area	Period	N	Median	MAD	IQR	Median	MAD	IQR
Africa	**1990-04**	**50**	**1.103**	**1.950**	**4.352**	**6.510**	**3.110**	**6.400**
	2005-19	**50**	**2.158**	**1.443**	**2.884**	**5.214**	**1.764**	**3.406**
Low income	1990-04	21	1.096	2.432	4.876	6.787	4.341	8.776
	2005-19	21	2.250	1.121	2.257	5.668	1.950	6.186
Lower middle income	1990-04	20	1.128	1.721	3.952	6.014	2.365	5.087
	2005-19	20	2.212	1.742	3.415	4.812	1.612	3.271
Upper middle income	1990-04	8	1.366	1.947	3.403	6.126	2.217	3.363
	2005-19	8	1.319	1.614	3.765	3.902	1.362	2.574
High income	1990-04	1	0.483	2.973	7.555	2.229	1.723	2.772
	2005-19	1	3.028	2.077	3.891	2.858	2.210	3.815
ROW	**1990-04**	**118**	**2.278**	**1.658**	**3.350**	**5.086**	**1.874**	**4.002**
	2005-19	**119**	**2.043**	**1.446**	**3.060**	**2.806**	**1.201**	**2.538**
Low income	1990-04	4	1.533	1.508	2.894	15.861	6.298	24.794
	2005-19	4	2.391	1.164	2.153	8.456	2.515	5.834
Lower middle income	1990-04	23	1.760	1.217	3.094	8.528	3.973	7.423
	2005-19	23	3.106	0.921	2.103	5.296	1.590	3.253
Upper middle income	1990-04	39	2.504	2.231	4.339	8.410	4.286	14.062
	2005-19	40	2.821	1.898	3.655	4.072	1.492	3.184
High income	1990-04	52	2.476	1.501	3.166	2.395	0.970	1.871
	2005-19	52	1.484	1.323	2.997	1.912	0.864	1.704

Data Source: IMF WEO, October 2021. Real GDP per capita growth is calculated using the constant national currency series (NGDPRPC), and inflation is based on average national consumer price indices (PCPIPCH).
Notes: Statistics are calculated at the country-level, and aggregated across countries using the median. Countries with < 9 obs. for growth or inflation in either 1990-04 or 2005-19 were excluded - in Africa Liberia, Somalia, South Sudan and Zimbabwe.

It remains to quantify the extent to which improvements in macroeconomic stability are also associated with larger growth and lower inflation within individual countries. Table 2 reports robust regressions of the difference in medians on the difference in the MADs of growth and inflation. The coefficients show a negative correlation between volatility and growth, and a positive relationship between inflation volatility and median inflation, which is sizeable for LICs and LMICs in Africa and ROW alike. Table 2 thus provides strong evidence that stabilization was also associated with better macroeconomic performance at the country level. These relationships have been studied empirically, starting with Ramey and Ramey (1995), though mostly in a pure cross-country setting. Among the more detailed analyses, Hnatkovska and Loayza (2005) document that the correlation between volatility and growth is negative for poor countries, basically zero for middle-income countries, and positive for advanced economies. Loayza et al. (2007) and Hallegatte and Przyluski (2011) also show that volatility in real output in developing countries is strongly related to consumption volatility, and hence incurs a large welfare cost.

Table 2: Output and Inflation Volatility: 2005-19 – 1990-04 Difference

Area		GDP/Capita			Inflation		
	N	β	P($\beta \neq 0$)	R^2	β	P($\beta \neq 0$)	R^2
Africa	**50**	**-0.294**	**0.004**	**0.164**	**0.469**	**<0.001**	**0.632**
Low income	21	-0.429	0.025	0.244	0.709	<0.001	0.747
Lower middle income	20	-0.111	0.379	0.043	0.322	<0.001	0.715
Upper middle income	8	0.218	<0.001	0.943	-0.108	0.743	0.020
ROW	**118**	**-0.126**	**0.018**	**0.046**	**0.713**	**<0.001**	**0.890**
Lower middle income	23	-0.432	0.039	0.182	0.920	<0.001	0.761
Upper middle income	39	-0.035	0.756	0.003	0.701	<0.001	0.915
High income	52	-0.087	0.247	0.027	0.250	<0.001	0.364

Data Source: IMF WEO, October 2021. See also note to Table 1.
Note: A regression of the the difference in medians on the difference in MADs of the country-series is run using a robust MM estimator following Koller and Stahel (2011). Available in R package *robustbase*.

The relationship here also holds at the cross-country level. Tables A1, A2 and Figure A2 in the Appendix present equivalent exercises with statistics computing over the whole 1990-2019 period for each country. Figure A13 further elicits the similarity of results using period averages or differences and indicates that the stabilization of growth rates is only mildly correlated with inflation stabilization. This corroborates the evidence that the past 3 decades, and particularly the years 1995-2012, have seen a remarkable positive change in real sector macroeconomic stability in Africa, both within individual countries and for the region as a whole, which persisted and advanced even under lower growth rates during the 2010s.

3 Decompositions of Output and Volatility

To investigate the causes of declining volatility in the long run, it is instructive to first examine in some detail the structure of production and consumption in Africa. Due to the greater theoretical relevance and decomposability, this section strongly concentrates on production, and only briefly comments on changes in expenditure on GDP.

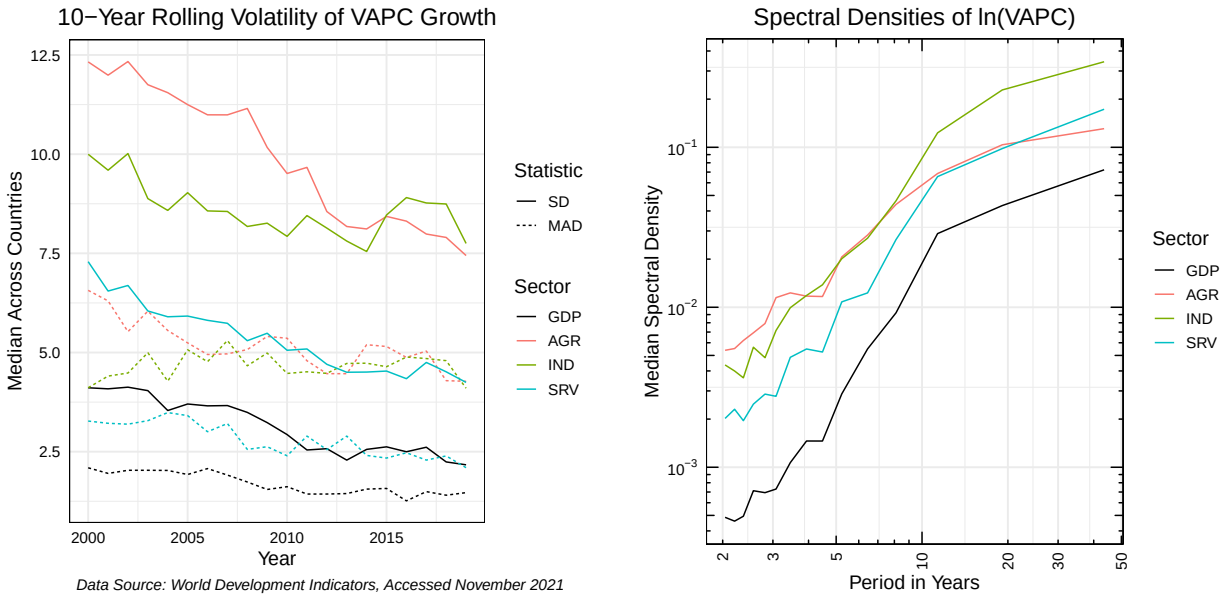
3.1 Production

Structural change in Africa since the 1990s, was characterized by an increasing GDP share of the services sector, and a declining share of agriculture[5]. This pattern is strongly reflected in the contribution of the sectors to GDP per capita growth rates[6]. For volatility analysis, I consider GDP at basic prices[7]. Figure 3 provides a broad view of sectoral volatility, measured by sectoral value-added per capita (VAPC), across both time and frequency. The left side of Figure 3 shows that growth volatility in all sectors has decreased over time. In the 1990-2000 decade, the agricultural sector was

[5]See Figure A14.
[6]See Figure A15, which also shows an increasing role of taxes.
[7]The tax component is extremely volatile.

the most volatile, but volatility decreased rapidly in the 2000s, approaching the volatility of industry. Volatility in services is much lower and has also declined continuously. The right-hand side of Figure 3 shows that agriculture is only more volatile than industry over short-run fluctuations with periods of < 4 years. Industry is the main source of volatility for longer-term variation with > 10 year periods, whereas the volatility of agriculture drops significantly at longer periods. The two sides of Figure 3 can be reconciled by considering, as shown by Shumway et al. (2000) and in Appendix Section 1, that first-differencing (or computing the growth rate) amounts to a high-pass filter that gives most weight to volatility at periods of 2 years and gradually down-weights volatility with higher periods[8].

Figure 3: Sectoral Volatility Across Time and Frequency



Data Source: World Development Indicators, Accessed November 2021

The relationship between aggregate and sectoral volatility is only linear if sectoral growth rates are statistically independent, which is not the case in economic reality. Therefore I proceed to consider a decomposition of aggregate volatility that incorporates sectoral covariances. Formally, let Y_t be the real GDP per capita at basic prices for a single country in period t. Aggregate GDP per capita is the sum of sectoral VAPC. Let there be K sectors indexed by k, then

$$Y_t = \sum_k y_{kt}. \tag{1}$$

Subtracting Eq. 1 at period $t-1$ from Eq. 1, and dividing through by Y_{t-1}, gives the GDP growth rate in terms of the contribution of sectoral shares, or, after multiplying and dividing by $y_{k,t-1}$, as the share-weighted sum of sectoral growth rates

[8]Section 1 of the Appendix contains a frequency domain analysis and discussion concerning volatility harmful to economic activity in Africa, and shows that the volatility of growth rates provides an acceptable proxy for such harmful volatility. The paper thus continues to focus on growth rates and the time domain, but readers should be mindful that this emphasizes the short term.

$$\frac{\Delta Y_t}{Y_{t-1}} = \sum_k \frac{\Delta y_{kt}}{Y_{t-1}} = \sum_k \frac{y_{k,t-1}}{Y_{t-1}} \frac{\Delta y_{kt}}{y_{k,t-1}} = \sum_k \theta_{k,t-1} \frac{\Delta y_{kt}}{y_{k,t-1}}, \tag{2}$$

where $\Delta Y_t = Y_t - Y_{t-1}$. I now consider the variance of real GDP per capita growth over the entire sample period: $var(\%\Delta Y) = E[(\%\Delta Y)^2] - E[\%\Delta Y]^2$, where $\%\Delta Y = \Delta Y / Y_{(t-1)}$. The variance of a sum of random variables is given by Bienames Identity[9], thus taking the variance of Eq. 2 yields

$$var(\%\Delta Y) = \sum_{k \in K} \sum_{j \in K} cov\left(\frac{\Delta y_k}{Y_{(t-1)}}, \frac{\Delta y_j}{Y_{(t-1)}}\right) \approx \sum_{k \in K} \sum_{j \in K} \bar{\theta}_k \bar{\theta}_j \; cov\left(\%\Delta y_k, \%\Delta y_j\right), \tag{3}$$

where $\bar{\theta}_k = \frac{1}{T-1} \sum_{t=2}^{T} \theta_{kt}$ is the average lagged output share of sector k over the observed period T. If there is no structural change during the period of observation ($\theta_{kt} = \bar{\theta}_k \; \forall \; t \in T$), the right side of Eq. 3 becomes an identity as well.

Computing Eq. 3 over the entire 1990-2019 period (Table A3), shows that agriculture is the most volatile sector, followed closely by industry, in line with Figure 3. The covariances are all negative and significantly smaller, with the largest in magnitude relationship between agriculture and industry, and the smallest between agriculture and services. These patterns are broadly preserved when considering contributions to aggregate volatility[10], but, due to the larger shares of industry and services in the GDP of most countries, these sectors and their covariance term take a larger share in aggregate volatility. Considering the robust estimates, and counting covariance terms twice following Bienames Identity, yields that aggregate volatility in the median African country over the 1990-2019 period is composed of 23.6% agriculture, 31.7% industry, and 59% services volatility, and the sum of these three is reduced by covariances summing to -14.6%.

Having examined Eq. 3 in aggregate terms, I now consider the change in aggregate per-capita growth volatility $\Delta var(\%\Delta Y)_\tau$, computed between two periods $\tau_1 = 1990 - 2004$ and as $\tau_2 = 2005 - 2019$. Using the left side of Eq. 3, this is equal to the sum of changes in the variances and covariances of the sectoral contributions to aggregate growth. To guard against outliers, I also use the comedian[11] as a robust alternative to the classical estimator. Another methodological ambiguity regards aggregation. Since the sectoral shares in aggregate moderation are of greater interest than differences in sectoral volatility, I can compute these shares at the country level before aggregating, or first aggregate the volatility differences and then compute shares. One might think of the former to be a better approach, but the data for some countries is of very poor quality so computing shares

[9] $$var(\sum_k a_k y_k) = \sum_{i \in K} \sum_{j \in K} a_i a_j cov(y_i, y_j) = \sum_k a_k^2 var(y_k) + 2 \sum_{1 \leq i} \sum_{< j \leq K} a_i a_j cov(y_i, y_j).$$

[10] See the bottom panel of Table A3.

[11] The comedian is defined as $com(X,Y) = med((X - med(X))(Y - med(Y)))$. It is not strictly a robust covariance estimator as it does not preserve the relative magnitude of variances and covariances. The implementation used attempts to correct for this though. In general, the robust covariance estimator of Stahel (1981) and Donoho (1982) used for Table A3 would be a better choice, but encounters problems converging in very small samples.

from Eq. 3 at the country level can result in very large numbers. I thus implement both approaches, but only report country-level shares aggregated across countries using the median. Together with the choice of covariance estimator this leads to 6 different estimation strategies.

Table 3: Sectoral Contribution to Moderation in GDP Volatility

CovEst	AggFun	Fit	$\Delta var(\%\Delta Y)_\tau$	AGR	IND	SRV	$\sum cov_{jk}$	2AI	2AS	2IS
					Sectoral Shares Computed After Aggregation					
Pearson	Mean	100%	-16.18	35%	3%	48%	13%	28%	-6.2%	-8.5%
Comedian	Mean	95%	-6.53	49%	-24%	37%	38%	9.7%	4.9%	24%
Pearson	Median	62%	-5.82	29%	0.84%	40%	31%	2.5%	11%	17%
Comedian	Median	29%	-1.25	45%	0.71%	18%	37%	7.9%	8.7%	20%
					Sectoral Shares Computed Before Aggregation					
Pearson	Median	100%	-5.82	23%	14%	46%	17%	3.9%	3.5%	9.6%
Comedian	Median	68%	-1.25	20%	23%	31%	26%	5.9%	14%	6.8%
Median of 6 Estimates:		81%	-5.82	32%	1.9%	38%	28%	6.9%	6.8%	13%

Notes: The 'Fit' column signifies how closely Eq. 3 is satisfied, columns AGR, IND, and SRV give the sectoral contribution to the aggregate volatility reduction in percentage terms, and $\sum cov_{jk}$ gives the combined contribution of all covariance terms, which are also individually broken down in columns 2AI, 2AS and 2IS. Estimates differ depending on the covariance estimator, aggregation function, and whether shares are computed before or after aggregation. The bottom row shows the median of all 6 reported estimates.

Table 3 reports the results, and shows that the reduction in volatility $\Delta var(\%\Delta Y)_\tau$ is due to both reductions in sectoral variances and sectoral covariances[12]. The results differ a bit depending on the methodology: estimates involving Pearson's covariance generally satisfy the equation much more closely, but are also most affected by outliers. To generate a representative estimate summarizing the exercise, I compute the median across all 6 strategies and report it in the final row of Table 3. The outcome suggests that 32% of the aggregate reduction in per capita volatility between τ_1 and τ_2 was accounted for by agriculture, 38% by services, and 28% by a reduction in the covariances, of which, abbreviating sectors by their first letter, around 7% are accounted for by AI and AS, and 13-14% by IS. The idiosyncratic reduction in industrial volatility here only accounts for 1.9% of the aggregate volatility reduction. The results thus confirm a more than proportional role of agriculture in the African Moderation, but also signify a shift towards greater sectoral independence, or rather, sectoral substitutability - implied by a observed median increase in the negative covariance between AI and AS, and a shift from a small positive IS covariance in τ_1 to a small negative covariance in τ_2.

A shortcoming of the results of Table 3, based on the left side of Eq. 3, is that they include the effects of structural change. To examine the contribution of structural change in isolation, I further develop the right side of Eq. 3, and decompose changes in aggregate volatility into changes in sectoral volatilities and changes in sectoral production shares. This is motivated by the consideration that the service sector is substantially less volatile than agriculture and industry, and the share of services in African GDP has been increasing, thus a quantifiable fraction of the aggregate moderation

[12] Mostly expressed through already negative covariances becoming more negative, so not a covariance reduction in absolute terms.

must be a direct consequence of structural change. This type of decomposition is well-known in the structural change literature. McMillan and Rodrik (2011) decompose changes in aggregate labour productivity as[13]

$$\Delta LP_t = \Delta \sum_k \theta_{kt} lp_{kt} = \sum_k \theta_{k,t-1} \Delta lp_{kt} + \sum_k \Delta\theta_k lp_{kt}, \tag{4}$$

where $\theta_{k,t-1}\Delta lp_{kt}$ denotes the sectoral labor productivity changes weighted by sector shares at the beginning of the period, and $\Delta\theta_k lp_{kt}$ denotes the changes in sectoral shares weighted by final period productivity levels[14]. Applying Eq. 4 to the right side of Eq. 3 yields

$$\Delta var(\%\Delta Y)_\tau \approx \sum_{k\in K}\sum_{j\in K} \bar{\theta}_{kj,\tau-1}\ \Delta cov\left(\%\Delta y_k, \%\Delta y_j\right)_\tau + \sum_{k\in K}\sum_{j\in K} \Delta\bar{\theta}_{kj,\tau}\ cov\left(\%\Delta y_k, \%\Delta y_j\right)_\tau, \tag{5}$$

where $\tau = (t, \ldots, t+N-1)',\ N \in 2, \ldots, T$ denotes a time-window of size N over which the covariance is computed, and $\bar{\theta}_{kj\tau} = \frac{1}{N-1}\left(\sum_{i=1}^{N-1}\theta_{k,t+i} \times \sum_{i=1}^{N-1}\theta_{j,t+i}\right)\ \forall\ k, j$ denotes the product of the average sectoral shares. The first weighted sum of covariances in Eq. 5 thus captures changes in aggregate volatility resulting from changes in volatility within sectors, and the second changes in aggregate volatility due to the shifting of value-added between sectors at different levels of volatility. I estimate Eq. 5 considering again a single difference between periods τ_1 and τ_2. Estimation is done using both classical and comedian covariance estimators, computing shares before or after aggregation across countries using the median[15].

Table 4 reports the results. Columns 'Within' and 'Between' give the median value of the respective components in Eq. 5, which were transformed into shares before aggregation if 'Trans = Share'. 'Fit' indicates how closely Eq. 5 is satisfied, and columns 'Within/Sum' and 'Between/Sum' provide the percentage shares of the two components in their sum i.e. relative to the overall fit, as in Table 3. If 'Trans = Share', these columns are also computed before aggregation.

[13] Equation 4 is derived as: $\Delta LP_t = \sum_k \Delta(\theta_{kt} lp_{kt}) = \sum_k(\theta_{kt} lp_{kt} - \theta_{k,t-1} lp_{k,t-1}) = \sum_k(\theta_{kt} lp_{kt} - \theta_{k,t-1} lp_{k,t-1} + \theta_{k,t-1} lp_{kt} - \theta_{k,t-1} lp_{kt}) = \sum_k(\theta_{k,t-1}\Delta lp_{kt} + \Delta\theta_k lp_{kt})$.

[14] The different timing of the weights masks a covariance term ($\Delta lp_{kt}\Delta\theta_{kt}$), elicited by de Vries et al. (2015), capturing the movement of labor to sectors with higher productivity growth, but for the purposes of this paper, the decomposition of de Vries et al. (2015) is too complicated

[15] Eq. 5 is even more sensitive to outliers than Eq. 3, and is not completely satisfied even by Pearsons covariance, therefore aggregation across countries using the mean does not make much sense.

Table 4: Stuctural Change and African Moderation

CovEst	Trans	$\Delta var(\%\Delta Y)_\tau$	Within	Between	Fit	Within/Sum	Between/Sum
World Bank Data (3-Sectors, 41 Countries)							
Classical	None	-5.823	-2.390	-0.141	43.5%	94.4%	5.58%
Classical	Share	-5.823	0.958	0.019	102%	97.0%	2.98%
Comedian	None	-1.669	-2.506	-0.147	159%	94.5%	5.53%
Comedian	Share	-1.669	0.757	0.045	88.7%	96.9%	3.07%
Economic Transformation Database (12-Sectors, 21 Countries)							
Classical	None	-6.304	-5.002	-0.002	79.4%	100%	0.03%
Classical	Share	-6.304	0.993	0.001	105%	98.1%	1.85%
Comedian	None	-2.775	-3.413	-0.111	127%	96.8%	3.16%
Comedian	Share	-2.775	0.969	0.037	113%	96.9%	3.07%

Notes: The decomposition is computed at the country level for 41 African countries according to Eq. 5, comparing the 1990-2004 to the 2005-2019 period. The 2 components are turned into shares if 'Trans = Share', and aggregated across countries using the median. Further descriptions of the columns are provided in the main text. 13 countries with less than 10 observations for any sectoral growth rate in either period were excluded: Algeria, Angola, the Central African Republic, Djibouti, Equatorial Guinea, Eritrea, Kenya, Liberia, Libya, Madagascar, Somalia, South Sudan, and São Tomé & Príncipe. The ETD of Kruse et al. (2022) records 12 sectors for 21 African countries: BFA, BWA, CMR, EGY, ETH, GHA, KEN, LSO, MAR, MOZ, MUS, MWI, NAM, NGA, RWA, SEN, TUN, TZA, UGA, ZAF, ZMB.

Table 4 shows that in the median country structural change explains between 3% and 5.6% of the aggregate reduction in per-capita growth volatility between τ_1 and τ_2. This result is robust across methodological choices. A concern here may be that a 3-sector setup is too broad to quantify the effects of structural change on aggregate volatility. Thus I also repeat the exercise with a more detailed dataset used in the structural change literature: the Economic Transformation Database (Kruse et al., 2022), provides a disaggregation into 12 sectors for 21 African countries, over the period 1990-2018, and can thus also be split between τ_1 and τ_2. The bottom half of Table 4 reports the results, indicating that even with a finer sectoral disaggregation, the contribution of pure structural change to African Moderation is smaller than 5%.

The analysis presented in Tables 3 and 4 thus establishes that up to 30% of the aggregate African moderation of real per-capita growth rates, is due to changes in the covariance towards greater sectoral independence/substitution, and up to 5% can be attributed to pure structural change, with less volatile sectors like services becoming economically more important. The remaining 65-70% are due to other factors which affected mostly agriculture and services, with a stronger effect on agriculture. More analysis will hence be needed to examine the contribution of other economic, political, social, and structural factors to the African moderation in aggregate output and inflation. With reference to the great moderation literature, a frequently mentioned driver in advanced economies (Blanchard and Simon, 2001; Horan, 2006) is greater efficiency in production through innovations affecting inventory management. Given the small role of the industry sector in Africa's moderation, the results suggest that inventory management is unlikely to be an important driver of moderation in Africa.

Before examining other factors, I validate these results at the country level and uncover some heterogeneity. Towards this end I first classify countries according to their greatest sectoral source of volatility over the entire 1990-2019 period. For this I compute two metrics, the MAD sector contribution to GDP growth, MAD$(\Delta y_t/Y_{t-1})$, and a penalized measure of sectoral growth volatility defined as MAD$(\%\Delta y_t) \times$ MAD$(\Delta y_t/Y_{t-1})$, where the multiplication with MAD$(\Delta y_t/Y_{t-1})$ acts as a weight to penalize volatile but economically small sectors. I call this measure the sector's volatile growth risk, as it captures a sector's volatility, but also an element of risk posed by the sector for aggregate growth volatility.

Considering the sectors volatility contribution [MAD$(\Delta y_t/Y_{t-1})$], the largest group of 21 countries has services as the greatest contributor to aggregate volatility, followed by industry (17) and agriculture (13) (see Table A4). This metric thus broadly aligns with the pattern of structural change. Considering the sector volatile growth risk metric, however, leads to a large reallocation of countries to industry and agriculture, with 20 countries having growth risks in agriculture and 21 in industry, with only 10 countries remaining in the services category (see bottom half of Table A4). The group of countries with growth risks in Agriculture comprises both agricultural economies like Burundi and Niger, but also agricultural exporters like Uganda, Kenya, and Tunisia. Industry comprises both countries with some industry like Egypt and Namibia, but also countries active in mining like Botswana and the DRC, and oil exporters like Angola, Nigeria, and the Republic of Congo. The services category comprises mostly smaller service-oriented economies like Benin, Ghana, and Rwanda.

These metrics can also be used to track changes in sectoral volatility within countries over time. For this I compute the volatility measures for τ_1 and τ_2, and count the number of countries above the median volatility across countries and periods on each metric (see Table A5). In agriculture, the number of countries with above-median volatile growth risk declined from 31 in 1990-2004 to 17 in 2005-2019, with smaller reductions of risk in services (28 to 20) and industry (26 to 22). Only slightly weaker development is exhibited considering the sectoral volatility contributions.

The Appendix also provides more disaggregated views: Figure A18 visualizes the movement in the sectoral growth risk indicator for all countries and shows a nearly ubiquitous and large stabilization of agriculture, as well as a sizeable stabilization of services in most countries. In industry, the developments are very heterogeneous, with some countries like Ghana experiencing greater volatility in industry, and others like South Africa experiencing significant stabilization. It is also interesting to compare different regions in Africa. Figure A19 and Table A6 provide a regional summary of sectoral volatility and show that the greatest stabilization in agriculture was experienced in Eastern, Northern, and Western Africa, in this order. Middle Africa experienced a large stabilization in the service sector. Overall, Eastern Africa experienced the largest stabilization in aggregate output, followed by Middle and Western Africa.

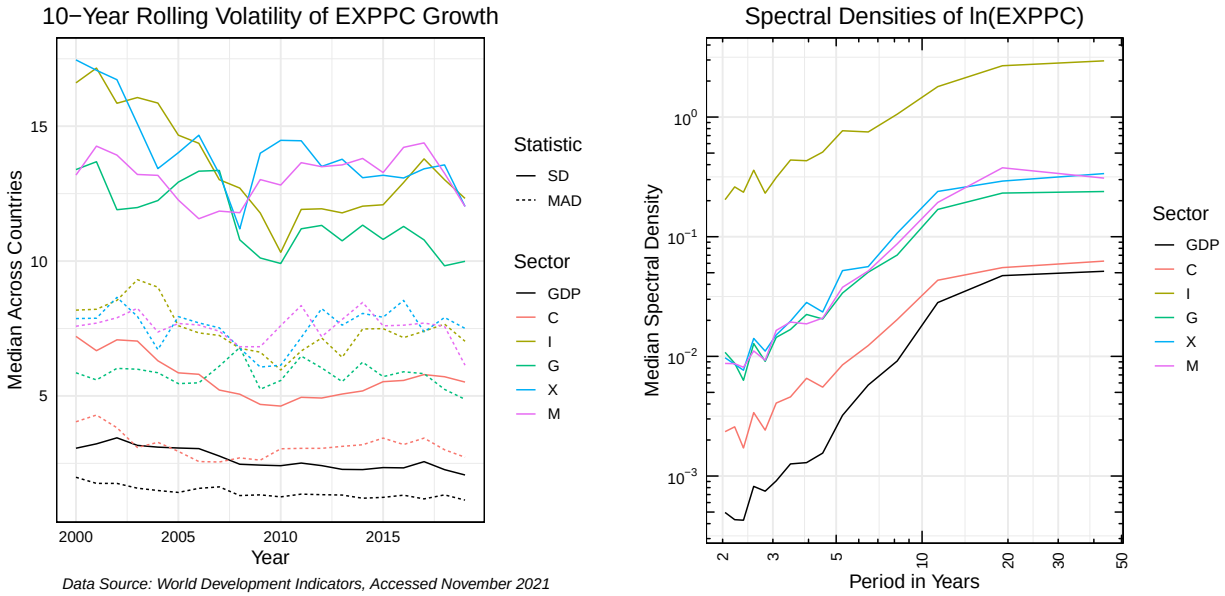
Disaggregated analysis hence confirms the results of aggregate analysis, and indicates that stabilization of agriculture and services was a shared experience for most African countries since 1990. There is moderate regional heterogeneity, with the more developed regions of Northern and Southern Africa being affected less, and Eastern Africa emerging as the most stable African region, following a large stabilization encompassing all 3 broad sectors.

3.2 Expenditure on GDP

Having analyzed production in detail, I briefly examine the expenditure side of GDP. Figures A20 and A21 show the expenditure shares and contributions to per-capita growth at the continent level. Overall the shares are relatively stable. Investment has increased slightly, climbing from $\sim 20\%$ in 2005 to $\sim 25\%$ in 2012. Exports and imports also both increased gradually until 2012, and then began to fall, with exports falling more than imports, yielding a higher aggregate trade deficit.

The left panel of Figure 4 shows the aggregate decline in volatility, which, on the expenditure side, is accounted for essentially in absorption i.e. aggregate declines in the volatility of consumption, investment, and government spending, in particular before 2010. The right panel of Figure 4 shows that from a frequency domain perspective, investment is the most volatile component at all frequencies (exempting net exports). Consumption is the least volatile component, and approaches the volatility of GDP at lower frequencies.

Figure 4: Expenditure Volatility Across Time and Frequency



Data Source: World Development Indicators, Accessed November 2021

More detailed decompositions of aggregate volatility from the expenditure side are omitted, due to difficulties with net exports accounting[16]. Linking production and expenditure side data is also

[16] A covariance matrix analogous to Table A3 is provided in Appendix Table A7. This shows large negative covariances

difficult without detailed breakdowns, but the large declines in agriculture and service sector volatility are likely reflected on the expenditure side in the decline in consumption volatility, but also declining volatility of the merchandise trade balance (see Section 4). Thus at large, I leave a detailed analysis of expenditure dynamics for further research.

of imports with absorption and exports, indicating the endogeneity of net exports and the difficulties to account aggregate changes in volatility from the expenditure side.

4 External, Financial and Policy Factors

So far I have documented the extent of macroeconomic moderation in Africa, and established that 65-70% of it cannot be explained by structural change or changes in the covariance structure of production. The remainder of the paper thus examines other contributing factors, including the external economic environment faced by African economies, changes in the financial sector, macroeconomic policies, and other changes in economic or institutional structure (Section 5).

Several papers have investigated the causes of macroeconomic moderation in the US and other advanced economies along similar lines. Horan (2006) investigates the causes of the reduction of output volatility in advanced economies, focussing on the competing explanations of better monetary policy leading to lower inflation, more efficient inventory investment of firms, and lower exposure to global shocks (oil price shocks). He finds that, due to the different onsets of output moderation in advanced economies, only the former two provide credible explanations for the great moderation. Particularly inventory investment volatility is highly correlated with GDP volatility in all advanced economies. Blanchard and Simon (2001) also find evidence that more countercyclical inventory management, by virtue of new information technologies helping to plan production and sales, has contributed to the stabilization of business cycles in the US. Schmidt-Hebbel (2009) discusses causes of the great moderation in emerging markets and developing economies (EMDE's), mentioning stronger policies and policy consensus, and better institutions (especially improved property rights, better governance and accountability of governments, greater central bank independence) as drivers of macroeconomic moderation. Many developing countries also adopted more sustainable fiscal policies, monetary policies focused on price stability, and more flexible exchange rate regimes. Schmidt-Hebbel (2009) further documents that the adoption of inflation targeting monetary policy (IT) in EMDE's was associated with reduced domestic inflation and exchange rate pass-through, particularly in EME's.

With regard to Africa, little is known about the evolution of inventory management practices, but I have argued against it based on the small contribution of the industrial sector to African moderation. I will also argue against IT as a driver of moderation in Africa. There have, however, been notable changes in the external environment faced by African economies in this time frame, reflected in better terms of trade (ToT), lower external debt burdens, higher inflows of FDI and remittances, as well as lower volatility of merchandise trade, FDI and remittance inflows. There has also been a gradual process of financial deepening, reflected in broad money, credit to the private sector, national savings, and reserve assets. Finally, there have been changes toward a more successful exchange rate policy, and the widespread adoption of fiscal rules. In the following subsections, I discuss these developments, and provide some evidence that these factors have likely played a role in the African moderation.

4.1 External Environment

Enhanced growth and reduced volatility may partly be consequences of a more favorable external environment faced by African economies in this time frame, permitting both stronger growth and more long-term economic planning and investments, leading to greater macroeconomic stability. It is notable from Figure 1 that growth rates peaked shortly after 2010, which, thanks to the Heavily Indebted Poor Countries (HIPC) Initiative launched in 1996, is also the period when Africa faced the lowest levels of public and external debt (see Figure A22). African economies also experienced more favorable terms of trade (ToT) and higher FDI and remittances inflows after 2010.

Table A8 shows correlations of 10-year rolling averages of these indicators with rolling medians and MADs of per-capita growth and inflation, in country-standardized first-differences. ToT and FDI are significantly positively correlated with growth, whereas public and external debt are strongly negatively related to growth. In addition, higher ToT and remittances are associated with lower growth volatility and levels of inflation, whereas greater debt stocks correlate with higher volatility and inflation. This indicates that more favorable linkages with the World may have contributed to the increased resilience in African real sectors. Looking forward, the increased resilience of the past 2 decades must be evaluated against the sharply rising debt levels in recent years.

A less volatile external environment may also have directly contributed to less volatile domestic activity. Figure A23 shows that exchange rate, ToT, and merchandise trade volatility have dropped substantially over the sample period, and also FDI and remittance flows became less volatile. Current account volatility also fell after 2010. Table A9 again shows corresponding within-country correlations of 10-year rolling volatility measures, indicating that higher exchange rate, ToT, and remittance volatility are indeed associated with lower growth and higher inflation levels. Especially exchange rate volatility is strongly related to inflation and inflation volatility. In short, higher volatility in all 6 indicators is positively correlated with higher growth and inflation volatility, and decreased during the past 15 years up to 2019.

4.2 Financial Deepening

Another source of increased resilience in Africa may be financial deepening, which acts as a domestic shock absorber, as well as increased levels of international reserves to counter external shocks. For example Easterly et al. (2001) analyze volatility with an emphasis on the financial sector, and find that domestic credit constraints are an important source of volatility in developing countries. They constate that domestic credit in developing economies has a boom-bust cycle of its own causing aggregate volatility, and that financial depth as measured by the overall volume of private sector credit to GDP works as a stabilizing factor. Figure A24 indicates that Africa has indeed made some progress in this direction over the past 30 years. Gross National Savings has increased from around 14% of GDP in 1990 to around 18% in 2019, total reserves have risen to around 100% of external

debt or 5.5 months of imports of goods and services, domestic credit to the private sector has risen from 17% to 25% of GDP, broad money from 30% to 40% of GDP, and banks liquid reserves to assets ratio has risen from <20% to >=25%, at least when weighted by GDP or population. Table A10 shows the corresponding correlations in country-standardized first-differences, indicating that higher national savings, reserves, domestic credit to the private sector, and broad money correlate with stronger economic growth and greater macroeconomic stability.

4.3 Macroeconomic Policies

Having briefly considered the external environment and the domestic financial system, it is also of great interest to examine the extent to which domestic macroeconomic and financial policies may have contributed to the African moderation. Here I consider the most important of such policies: managing inflation and the exchange rate, macroprudential stringency, and fiscal rules.

Inflation Targeting

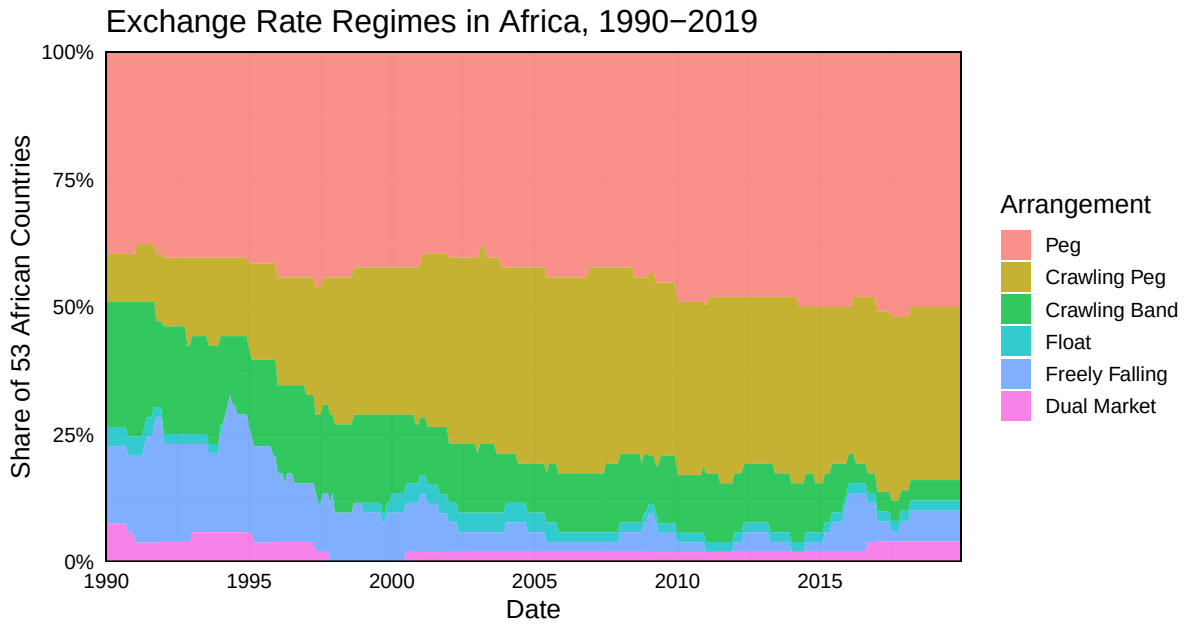
Africa still has very few inflation targeters. According to the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) database, only 4 countries currently target inflation: South Africa from 2000, Ghana from 2007, Uganda from 2011, and Seychelles from 2019. Figure A25 shows the inflation rates of these countries, indicating that the IT regimes were adopted when inflation had already stabilized to levels well below 20%. Thus adoption of IT did not play a large role for the African moderation documented in this paper.

Exchange Rate Arrangements

To examine the effects of different exchange rate regimes, I take data from Ilzetzki et al. (2019), available for 53 African countries. Figure 5 shows that the share of crawling bands and chaotic arrangements[17] has been declining in Africa since 1992, in favor of crawling peg arrangements. Free floats are also rare, and since 2005 only South Africa has maintained a floating regime.

[17] Comprising the categories 'Freely Falling' and 'Dual market in which parallel market data is missing' from Ilzetzki et al. (2019).

Figure 5: Exchange Rate Regimes in Africa



Data Source: Ilzetzki, Reinhart and Rogoff (2019)

To evaluate the effect different exchange rate regimes might have on macroeconomic volatility in Africa, Table 5 reports 15-year rolling panel regressions of growth and inflation volatility on the exchange regime dummies, using the hard peg as a base category. Each specification is estimated with pooled OLS[18], country fixed effects and country and time fixed effects, and all estimations are adjusted with Driscoll and Kraay (1998) (cross-)serial correlation consistent standard errors[19].

[18] Pooled OLS is mildly rejected by panel-Hausman tests, but included as a reference.

[19] Hoechle (2007) shows that Driscoll and Kraay (1998) standard errors also perform acceptably well in panels with a shorter time dimension of 10-25 periods.

Table 5: Exchange Rate 15-Year Rolling Panel-Dummy-Regressions, 1990-2019

Dependent Variable:	MAD Real GDP/Capita Growth (%)			MAD Inflation (%)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Crawling Peg	-0.5017***	-1.030**	-0.8594*	-0.2853	5.676	6.576
	(0.1213)	(0.4212)	(0.4743)	(0.4360)	(10.57)	(10.68)
Crawling Band	-0.7126**	0.2733	-0.0654	-0.5408	19.72**	18.62*
	(0.2486)	(0.6678)	(0.5721)	(2.155)	(8.871)	(9.523)
Float	-1.227***	1.325	0.7436	-1.756	46.70*	46.38*
	(0.1489)	(1.067)	(0.7344)	(1.161)	(22.06)	(21.93)
FF + DM	0.3907***	1.288***	0.4496	46.42**	117.5***	114.7***
	(0.1044)	(0.3280)	(0.2781)	(17.21)	(26.13)	(27.07)
Fixed-effects						
Country	–	52	52	–	52	52
Year	–	–	15	–	–	15
Fit statistics						
Observations	751	751	751	759	759	759
R^2	0.026	0.733	0.743	0.198	0.474	0.477
Within R^2		0.030	0.010		0.254	0.220

Driscoll and Kraay (1998) (L=1) standard-errors in parentheses *Signif. Codes:* ***: 0.01, **: 0.05, *: 0.1
Avg. Country Group Sizes: Peg: 22.8, Crawling Peg: 17, Crawling Band: 6.4, Float: 1, FF: 2.9, DM: 0.9

Notes: 15-year MAs of the exchange regime dummies on data from 1990-2019 (thus retaining 15 observations per country) are regressed onto 15-year rolling MADs of GDP per capita growth and CPI inflation (IMF WEO).

Table 5 demonstrates that, relative to the hard peg, crawling pegs are associated with greater growth stability, whereas more liberal regimes correlate with less stable growth performance. The coefficients on model (3) with the full set of fixed effects imply that a crawling peg is associated with a 0.86 percentage point decrease in the MAD of real per-capita growth vis-a-vis the hard peg arrangement. For inflation, the hard peg appears to be the most stable regime, but the coefficient on the crawling peg is insignificant, indicating that the inflation cost of switching to a crawling peg is moderate. The magnitude and significance of the coefficients on more liberal arrangements, and the high within-R^2 of around 0.25 in models (5) and (6), suggests that African countries with more liberal exchange rate regimes incur significant inflation volatility from exchange rate pass-through.

Since the largest shift in exchange rate regimes in Africa since 1990 has been an increase in crawling pegs and a decrease in more flexible and chaotic regimes, and Figure A23 shows a strong decline in exchange rate volatility over the period, these results suggest that this shift in exchange rate policy has contributed to Africa's macroeconomic moderation.

Macroprudential Regulation

Macroprudential policy and its role in safeguarding financial and macroeconomic stability received increased research attention in the aftermath of the 2008/09 global financial crisis. The IMF adopted a new Institutional View (IV) in 2012, recognizing the usefulness of macroprudential measures for macroeconomic stability, in particular in economies with less developed financial markets (Arora et al., 2013; IMF, 2017, 2022). Figure A27 shows indices of total, inflow, and outflow control measures across 18 African countries present in the macroprudential measures database of Fernández et al.

(2016) (August 2021 update), obtained as an arithmetic average of 20 dummy measures for inflow and outflow restrictions in different financial markets. Macroprudential measures have eased in the 1995-1997 period[20], but have remained quite stable around 0.5 for inflow measures and 0.625 for outflow measures afterward. It is therefore unlikely that aggregate macroeconomic moderation in Africa is much affected by changes in macroprudential policy.

When considering overall restrictiveness in the 10 different markets separately, some continent-level developments emerge. Figure A26 shows 10-year MAs of the overall stringency in 18 African economies, indicating that bond and guarantee markets, as well as FDI, have become more restricted in recent years, whereas equity, real estate, and commercial credit markets have become less restricted. At the level of individual African countries, macroprudential measures do appear an effective means of curbing volatility. Table 6 shows 10-year rolling regressions of the MADs of GDP per capita growth and inflation on the macroprudential stringency indicators[21]. The results imply that macroprudential stringency is negatively associated with both output and inflation volatility. Drawing from the specification with country and time fixed effects, an increase in overall macroprudential stringency by 0.1 is associated with a 0.54 percentage point reduction in the MAD of per-capita growth, and a 1.22 percentage point reduction in the MAD of inflation. Disaggregating into inflow and outflow measures shows that outflow measures have a stronger association with output stability, whereas inflow measures are strongly associated with reduced inflation volatility. Outflow measures do not have a statistically significant effect on inflation stability.

Table 6: Macroprodential Policy: 10-Year Rolling Panel-Regressions, 1995-2019

Dependent Variables:	MAD Real GDP/Capita Growth (%)			MAD Inflation (%)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Overall Measures	0.1724	-5.095***	-5.368***	2.497	-10.23*	-12.17***
	(0.1264)	(0.7261)	(0.7969)	(1.966)	(4.871)	(3.644)
R^2	0.004	0.512	0.602	0.007	0.344	0.388
Within R^2		0.153	0.196		0.004	0.007
Inflow Measures	0.3058***	-0.5994	-2.215***	9.942*	-7.188***	-21.25***
	(0.0654)	(0.7604)	(0.5578)	(5.142)	(2.314)	(2.018)
Outflow Measures	-0.0717	-4.096***	-3.050***	-5.008**	-3.473	5.768
	(0.1187)	(1.034)	(0.9308)	(1.978)	(3.277)	(4.398)
R^2	0.006	0.520	0.603	0.035	0.344	0.392
Within R^2		0.167	0.197		0.004	0.013
Fixed-effects						
Country	–	18	18	–	18	18
Year	–	–	16	–	–	16
Observations	288	288	288	287	287	287

Driscoll and Kraay (1998) (L=2) standard-errors in parentheses *Signif. Codes:* ***: 0.01, **: 0.05, *: 0.1

[20] Mainly due to liberalizations in Ethiopia, Nigeria, Uganda, and Ghana.

[21] 10 and not 15-year rolling regressions are used because data are only available from 1995, and to maintain a greater number of observations in the sample.

Fiscal Rules

A fourth and important set of stabilization policies are fiscal rules. Global data on fiscal rules adopted since 1985 is available through the IMF Fiscal Rules Dataset (Davoodi et al., 2022b,a). The history of fiscal rules in Africa is compactly summarized in Table 7[22].

Table 7: A Chronology of Fiscal Rules in Africa

Entity	First Rule	Expenditure	Revenue	Budget Balance	Debt
Kenya	1997		1997		1997 (2019)
Cape Verde	1998			1998	1998
WAEMU[a]	2000		2000 (2015)	2000 (2015)	2000 (2015)
Namibia	2001	2010			2001
CEMAC[b]	2002			2002 (2008, 2017)	2002
Botswana	2003	2003 (2006, 2016)		2003	2005
Nigeria	2007			2007	
Mauritius	2008				2008 (2010)
Liberia	2009				2009
EAC[c]	2013			2013	2013
Tanzania	2015	2015		2015	
Uganda	2016			2016	2016
Rwanda	2019			2019	

Revisions of existing rules indicated in parentheses.

[a] Comprising Benin, Burkina Faso, Côte D'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo
[b] Comprising Cameroon, Central African Republic, Chad, Republic of Congo, Equatorial Guinea and Gabon
[c] Comprising Tanzania, Kenya, Rwanda, Uganda, Burundi and South Sudan

Kenya was the first African country to introduce fiscal rules on revenue and debt in 1997[23], followed by Cape Verde with budget balance and debt rules in 1998[24]. Then, in 2000, the West African Economic and Monetary Union (WAEMU) put in place fiscal convergence criteria, including a budget balance rule limiting the fiscal deficit below 3% of GDP, a revenue rule setting the floor for revenues at 17% of GDP (revised to 20% in 2015), and a debt rule limiting public debt to 70% of GDP (Davoodi et al., 2022b). Namibia introduced a debt rule in 2001, followed by an expenditure rule in 2010[25]. The Central African Economic and Monetary Community (CEMAC) followed with debt and budget balance rules in 2002, which were revised in 2008 and 2017, to maintain a fiscal balance above -1.5% of GDP without accumulating arrears, and keep total public debt below 70% of GDP. Botswana followed in 2003 with expenditure and budget balance rules and added a debt rule in

[22] Figure A28 also shows an aggregate timeline of fiscal rules adoption in Africa by type and issuing authority.
[23] Revenue should be maintained at 21-22% of GDP. The debt rule was to keep public debt levels below 50% of GDP in net present value terms. The rule was amended in 2019 (Davoodi et al., 2022b).
[24] The ceiling on domestic borrowing was set at 3% of GDP, and a debt ceiling was set at 60% of GDP, but the debt ceiling is not legally binding (public debt is currently above it with no action being taken) (Davoodi et al., 2022b).
[25] The public debt was set at a range of 25-30 percent of GDP annually, which was revised to 35 percent of GDP. Debt servicing has been capped at less than 10 percent of revenues. The ceiling on government expenditure was set at 30 percent of GDP or below in a year, which was revised to less than 33 percent of GDP as part of the response to the pandemic (Davoodi et al., 2022b).

2005[26]. Nigeria adopted a budget balance rule in 2007[27]. Mauritius introduced a debt rule in 2008, which was revised in 2010[28], and Liberia introduced a debt rule in 2009[29]. In 2013, the East African Monetary Union (EAMU) adopted fiscal convergence criteria, setting a fiscal deficit of 3% of GDP to be achieved by FY2020/21, and a 50% ceiling on gross public debt in net present value terms. Tanzania further enacted an Oil and Gas Revenue Management Act in 2015, adding expenditure and budget balance rules[30], and Uganda added a Charter for Fiscal Responsibility consistent with the supranational requirements[31]. Rwanda added a budget balance rule in 2019 leading towards the supranational requirements[32].

In general, most fiscal rules in Africa must be regarded as weak. Apart from Mauritius and Botswana, no other country has instigated a formal enforcement procedure for its national rules, and also no country has an extra-governmental body to monitor compliance with national rules.

To evaluate the relationship of fiscal rules with macroeconomic stability, Table 8 presents 10-year rolling regressions considering first a dummy indicating adoption of any fiscal rule, then the total number of rules, and finally a set of dummies for the different types of rules. It is notable that adding both country and time-fixed effects lets the within R^2 drop to zero, indicating insufficient time variation in the fiscal rules to control for global events. The models with country-fixed effects however show a meaningful and significant stabilizing effect of fiscal rules for both growth and inflation. When disaggregating the set of rules, only the coefficient on the budget balance rule (BBR) is negative and significant in the regression on growth volatility. The size of the coefficient implies that a budget balance rule is associated with around 1% lower MAD of growth. For inflation, both Revenue and BBR have large negative coefficients. Debt rules are also negatively related to growth/inflation volatility, with insignificant coefficients between 0.23/0.54% in MAD terms.

[26] Expenditure was limited to fiscal targets embedded in the National Development Plan, which introduced a 40% of GDP government spending cap in 2006 (NDP9) and a target reduction of government spending to 30% of GDP by the end of FY 2015/16 (NDP10). The debt rule introduced in 2005 capped total domestic and foreign debt each to 20 percent of GDP (total 40 percent of GDP) (Davoodi et al., 2022b).

[27] The overall deficit ceiling was set at 3% of GDP. The authorities announced to bring the deficit down below the ceiling by end of 2022 and intend to keep the deficit at about 2.5% of GDP by 2023 (Davoodi et al., 2022b).

[28] The fiscal rules were defined in the 2008 Public Debt Management Act (PDMA). It underpinned a legally-mandated ceiling on debt at 60% of GDP until 2017 (initially target date by 2013 and was revised to 2017 in 2010). The debt ceiling was set to 50% of GDP in 2018. During the pandemic, the authorities repealed the debt rule to allow for support measures in response to COVID-19. Without an explicit debt anchor, the authorities laid out medium-term plans to reduce debt to less than 80% of GDP by the end of 2025 and to less than 70% by 2030(Davoodi et al., 2022b).

[29] The 2009 PFM Act introduced a debt ceiling rule limiting public debt to 60% of GDP and requiring that any borrowing be used to finance capital spending only.

[30] A ceiling on government spending was set at 40% of GDP coupled with a requirement to maintain current spending constant as a share of GDP. An additional non-oil and gas deficit ceiling of 3% of GDP was set (with oil and gas revenues excluded from revenues and treated as financing). The deficit rule applies only when oil and gas revenues are higher than 3% of GDP(Davoodi et al., 2022b).

[31] The charter qualified the ceiling of 50% of GDP on public debt in net present value terms, requiring the net present value of external debt to be maintained below 30% of GDP and the net present value of domestic debt below 20% of GDP(Davoodi et al., 2022b).

[32] The 5-year rolling average overall fiscal deficit ceiling was set at 5.5% of GDP from FY19/20 onwards (Davoodi et al., 2022b).

Table 8: Fiscal Rules: 10-Year Rolling Panel-Regressions with Data from 1990-2019

Dependent Variables:	MAD Real GDP/Capita Growth (%)			MAD Inflation (%)		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Dummy						
Any Rule	-0.4450	-0.8644***	0.7599*	-1.832***	-1.886***	0.5127
	(0.3045)	(0.1213)	(0.3743)	(0.2925)	(0.2921)	(0.4207)
R^2	0.008	0.710	0.732	0.148	0.448	0.504
Within R^2		0.070	0.011		0.163	0.003
Variable						
N. Rules	-0.2174**	-0.3574***	0.2266**	-0.6190***	-0.8204***	-0.0546
	(0.0998)	(0.0463)	(0.0831)	(0.1196)	(0.1126)	(0.1158)
R^2	0.015	0.710	0.731	0.123	0.461	0.503
Within R^2		0.070	0.007		0.184	< 0.001
Rule Dummies						
ER	-1.012***	0.3297*	0.4739**	-0.8629***	0.2318	0.4147
	(0.0984)	(0.1843)	(0.2173)	(0.2966)	(0.1978)	(0.2470)
RR	-1.115***	0.4285**	0.5313***	0.0267	-1.890***	-1.559***
	(0.0951)	(0.1581)	(0.1674)	(0.1617)	(0.1814)	(0.1607)
BBR	0.6600***	-0.9849***	-0.4113**	-0.2630	-0.7664**	-0.1291
	(0.1413)	(0.1603)	(0.1843)	(0.1701)	(0.3150)	(0.3817)
DR	-0.2568	-0.2262	0.6215*	-1.497***	-0.5366	1.158*
	(0.2932)	(0.2273)	(0.3534)	(0.2762)	(0.4100)	(0.5931)
R^2	0.050	0.716	0.733	0.145	0.474	0.524
Within R^2		0.088	0.016		0.203	0.042
Fixed-effects						
Country	–	25	25	–	25	25
Year	–	–	21	–	–	21
Observations	512	512	512	509	509	509

Driscoll and Kraay (1998) (L=2) standard-errors in parentheses *Signif. Codes:* ***: 0.01, **: 0.05, *: 0.1

The effectivity of fiscal rules for macroeconomic stability can also be evaluated more indirectly when considering their effect on important macroeconomic aggregates such as the current account (CAB), the government budget balance (GBB) and the level of gross government debt (GGD)[33]. Table A11 suggests that fiscal rules can have a beneficial effect on these macroeconomic aggregates. The existence and number of rules implemented correlates positively with the CAB and GBB, and negatively with the GGD level. When disaggregating rules, BBRs have a significant positive effect of an approx. 4.2% improvement in the CAB, and an even larger effect of around 7% on the GBB. Debt rules appear to have a large negative effect on levels of gross government debt, with large effect sizes of 70-80% lower debt.

Having considered four different types of macroeconomic policies in Africa over the past 30 years, it appears that only the shift towards crawling pegs from crawling bands and other less stable exchange regimes, and the adoption of fiscal rules in an increasing number of countries, can explain a part of the large macroeconomic moderation in growth and inflation observed over the same period. Inflation targeting monetary policy has only been taken up by four countries at a point when their inflation levels were already low and stable, and macroprudential policies, while potentially effective in curbing macroeconomic volatility, show no aggregate trend over most of the period under consideration. This assessment is of course not exhaustive in terms of potential changes in macroeconomic policy and their effects on macroeconomic conditions in Africa. For example, it is very possible that central banks have become more effective in targeting monetary aggregates without shifting to inflation targeting, or that many countries have run financial sector, trade, or agricultural policies that significantly contributed to macroeconomic stability.

[33] Figure A29 shows the values of these three aggregates, averaged across African and ROW countries. It is evident that CABs and GBBs in Africa have deteriorated since 2008/09, but GGD levels have improved through most of the period.

5 Structural Factors

An assessment of macroeconomic volatility and moderation would be incomplete without reference to various other structural characteristics of an economy, such as political and economic institutions, diversification in production and trade, economic openness, the incidence of conflicts and disasters, geography, human capital etc.. Significant literatures in economics have evaluated the effects of these factors in different contexts. For example, Acemoglu et al. (2003) analyze the effects of long-term institutional development on macroeconomic stability and find that countries that inherited more 'extractive' institutions from their colonial past are more likely to experience high volatility and economic crises. They further argue that poor institutions cause volatile and distortionary macroeconomic policies which act as a proximate cause for volatility. Rodrik (1999) relates the lack of persistent growth in developing countries to social conflicts, fuelled by factors such as inequality, ethnic fractionalization, etc., and weak institutions of conflict management and democratic governance.

Abdullahi and Suardi (2009) examine the effects of financial and trade liberalization on growth volatility of real output and consumption in Africa and show that trade liberalization is associated with greater output and consumption growth volatility, whereas financial liberalization increases the efficacy of consumption smoothing and stabilizes income and consumption growth. They also find that financial market depth and institutional quality interact with trade and financial openness to reduce volatility in output and consumption growth. Auffret (2003) investigates the effects of natural disasters on consumption volatility in the Caribbean region and argues that they have a direct impact on the stock of human and physical capital, which in turn negatively affects production, consumption, investment, and the current account balance. Malik and Temple (2009) examine the structural determinants of output volatility in developing countries, and especially the roles of geography and institutions[34] with Bayesian methods. They find an especially important role of market access: remote countries are more likely to have undiversified exports, high levels of export concentration, high ToT volatility, and high output volatility.

A significant literature has also evaluated the link between economic and trade diversification and macroeconomic volatility (Papageorgiou and Spatafora, 2012; Papageorgiou et al., 2015; Moore and Walkes, 2010; Koren and Tenreyro, 2007; Romeu and da Costa Neto, 2011; Rian and Arshbaf, 2015; Jansen et al., 2009), reaching a consensus that more diversified economies show lower volatility in variables such as GDP, consumption, investment, and exports, and are more resilient to external shocks. A key channel is that diversification involves LICs shifting resources from sectors where prices are highly volatile and correlated, such as mining and agriculture, to less volatile and correlated sectors, such as manufacturing and services, resulting in greater stability.

The effects of capital flows and transfers have also been heavily studied. Singh et al. (2011)

[34] Market access, climate variability, the geographic predisposition to trade, and various measures of institutional quality.

provide a macroeconomic study of remittances in SSA (36 countries from 1990 through 2005, with careful data preparation work), and find that remittances vary counter-cyclically with GDP per capita, consistent with the hypothesis that remittances can help mitigate economic shocks.

5.1 Cross-Sectional Analysis

In the following, I revisit most of these contributions in an attempt to ascertain which factors are most relevant for explaining volatility differences in a cross-section of African economies during the 1990-2019 period. For this, I selected 98 predictors jointly available for 49 African economies (excluding Djibouti, Liberia, Somalia, South Sudan, and Zimbabwe), with a total of 2.5% missing values. These include the vast majority of structural characteristics studied in the literature referenced above, and also the external environment and financial sector indicators studied in Sections 4.1 and 4.2. I group these 98 indicators into 19 topics, listed in Table 9, and with statistical details in Table A12.

Table 9: Indictor Topics for Cross-Sectional Prediction

#	Topic	Indicators
1	Institutions	9
2	Business Environment	4
3	Production Shares	2
4	Climate & Agriculture	8
5	Trade Intensity and Composition	7
6	Trade Diversification	4
7	Exchange Rate and Terms of Trade	5
8	Financial & Aid Flows	5
9	Financial Sector	6
10	Debt & Reserves	4
11	Population	6
12	Health	5
13	Education	5
14	Natural Disasters & Conflict	6
15	Geography & Accessibility	7
16	Natural Resources	2
17	Poverty & Inequality	3
18	Religion & Ethnicity	4
19	Others	6
	SUM	98

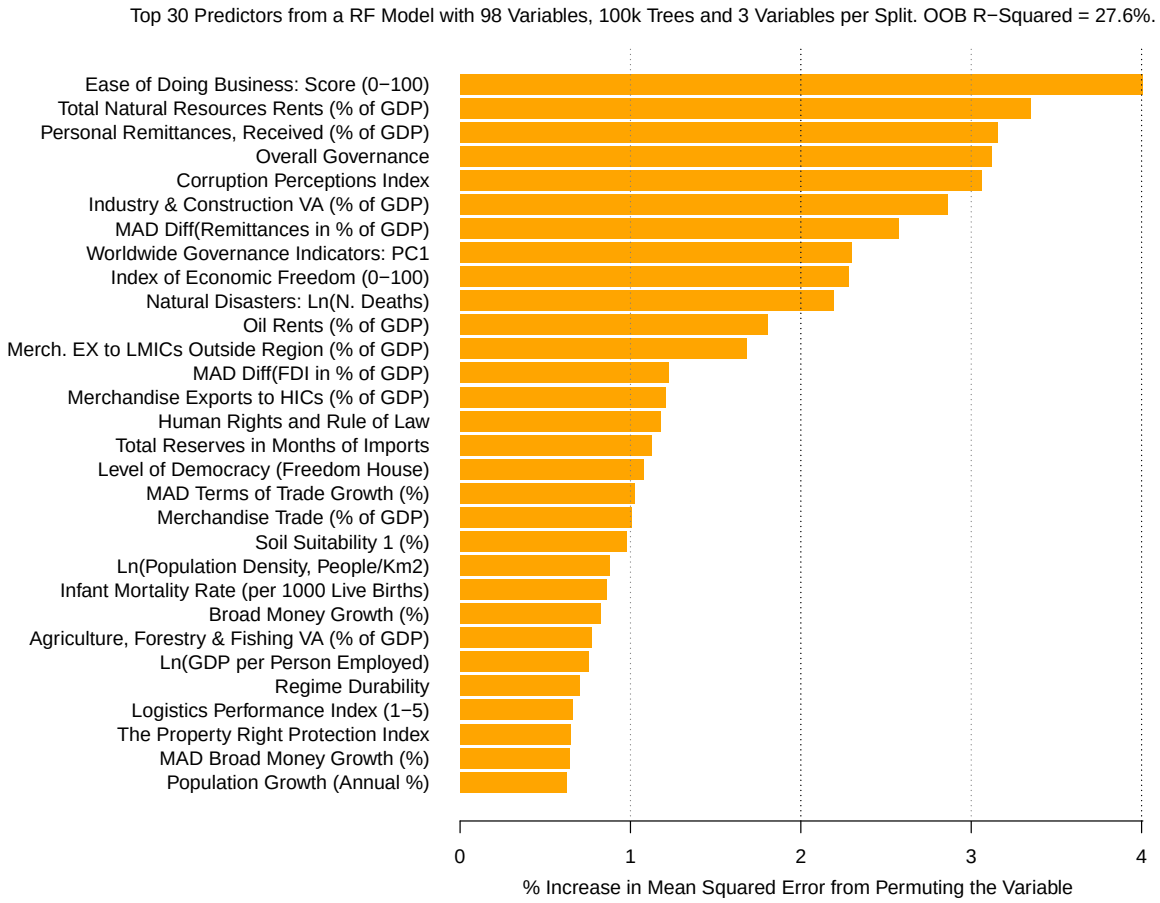
I then use a Random Forests (RF) machine learning model following Breiman (2001) to predict the volatility of per-capita growth and inflation, and determine the importance of different predictors, both individually and at the topic level. Initially, the RF model is used to predict the 2.5% missing values in the predictor dataset by an iterative algorithm called 'MissForest' developed by Stekhoven and Bühlmann (2012). Most predictors have no missing values (see Table A12), and no predictor

has more than 8 missing values[35].

To rank predictors individually, I first fit a regression forest of 100,000 highly de-correlated trees, grown to full size, with only 3 out of 98 predictors randomly chosen at each split. I determine the importance of each predictor by randomly permuting the observations of that predictor and measuring the increase in the Out-of-Bag (OOB) Mean Squared Prediction Error (MSE) caused by the permutation in percentage terms. Figure 6 shows the top 30 predictors of the MAD of GDP per capita growth over the 1990-2019 period. It is surprising that despite the high-dimensional dataset, the model only explains 28% of the variance in the outcome variable. There are 10 predictors whose permutation increases the MSE by more than 2%, and among these, there are 3 institutions, 2 business environment, and 2 remittance variables. The other top 10 variables are natural resource rents as a fraction of GDP, the share of industry in GDP, and natural disaster deaths. Among the variables that decrease predictive accuracy by more than 1% are also oil rents, trade with LMICs as a share of GDP, the MAD of FDI, total reserves, the cereal yield, human rights and level of democracy, the MAD of ToT growth and the trade share of GDP.

[35] Most of the 49 countries have 0, 1, or 2 missing predictors. Countries with more than 5 missing predictors are Comoros (8), Cape Verde (8), Eritrea (8), Democratic Republic of Congo (9), Libya (9), São Tomé & Príncipe (11), Seychelles (15) and Equatorial Guinea (16). To down-weight slightly the countries with more missing predictors, I use case weights equal to the number of non-missing predictors in the algorithm. The imputation has an average R^2 of 51%, with a minimum of 14% and a maximum of 81% for different predictors.

Figure 6: RF Predicting the MAD of PCGDP Growth of 49 African Economies in 1990-2019



Ranking the topics identified in Table 9 is not a straightforward task, as topics are both multi-dimensional and correlated. A first approach is to use the model underlying Figure 6 and just permute all predictors belonging to a certain topic and measure the decrease in predictive power. A problem with this method is that it does not attain the maximum predictive performance that could be obtained if a model were fit without the predictors in question. Thus another method would be fitting different models by excluding groups of predictors and comparing their performance to the baseline model with all predictors. This method can however also be criticized if different groups of predictors are correlated, as predictors in other groups will proxy for some of the variation captured by predictors from the excluded group in the full model. One possibility to limit this is to project all other predictors on the predictors of the excluded group and use the residuals to fit a new model[36]. In the face of methodological ambivalence, I employ all 3 methods and use the average rank based on the increase in MSE from permutation/exclusion/partialling out of the topical predictors to rank different topics in their importance. Table 10 reports the results. Overall, institutions emerge as the most

[36]The projection is done using linear regression, e.g. $Z(Z'Z)^{-1}Z'X$ where Z is a set of topical predictors and X the set of remaining predictors. If the set of topical predictors Z were large, this projection could also be done using an RF model, but with $<$10 predictors in Z the RF is not a sensible modeling choice.

important topic, followed by financial flows, trade intensity and composition, the financial sector, business conditions, natural resource intensity, natural disasters, and conflict. The permutation and exclusion methods provide a similar ranking of the top predictors, whereas the residual method sees trade intensity and financial sector characteristics as the most important predictors. It is also interesting to note that for several topics, exclusion from the model slightly increases the fit[37].

Table 10: RF Ranking of Indicator Topics: Predicting MAD PCGDP Growth, 1990-2019

Method:	Permutation		Exclusion		Residual Fit		Combined
Topic	%ΔMSE	Rank	%ΔMSE	Rank	%ΔMSE	Rank	Avg. Rank
Institutions	88.03	1	6.38	1	40.89	4	2.00
Financial & Aid Flows	73.47	2	4.29	2	43.69	3	2.33
Trade Intensity and Composition	57.63	4	1.90	7	53.93	1	4.00
Financial Sector	65.98	3	0.93	11	47.45	2	5.33
Business Environment	50.67	5	2.83	4	22.43	10	6.33
Natural Resources	28.81	12	3.20	3	34.28	5	6.67
Natural Disasters & Conflict	29.17	11	1.91	6	23.23	9	8.67
Production Shares	31.11	9	2.22	5	16.64	14	9.33
Population	31.17	8	0.75	12	27.72	8	9.33
Exchange Rate and ToT	29.18	10	0.39	14	29.41	7	10.33
Climate & Agriculture	45.07	6	-0.02	15	14.52	15	12.00
Health	16.62	16	1.47	8	20.49	12	12.00
Others	28.06	13	-0.21	18	31.10	6	12.33
Geography & Accessibility	20.78	14	-0.06	16	22.34	11	13.67
Trade Diversification	20.78	15	-0.12	17	18.50	13	15.00
Debt & Reserves	32.33	7	-0.57	19	5.39	19	15.00
Education	13.00	17	1.38	10	11.14	18	15.00
Poverty & Inequality	7.27	19	1.41	9	13.07	17	15.00
Religion & Ethnicity	10.90	18	0.55	13	14.12	16	15.67

There remains an additional caveat with these results, which is that topics are represented by differing numbers of indicators in the model. As Table 9 shows, the representation varies from 9 proxies for institutional quality to 2 proxies for production shares and natural resources. Having more proxies for a topic allows them to, prima facie, span a higher dimensional space and account for more variance of the outcome variable. On the other hand, one could contend that some constructs like institutional quality are inherently more high-dimensional than others like natural resource dependence. An imperfect way to compare the relevance of different topics under the assumption of equal dimensionality is to take the first 2 principal components (PC12) of the predictor space for each topic instead of the predictors themselves[38]. The results are reported in the Appendix: Table A15 shows the proportion of variance accounted for by PC12, and Table A16 gives results analogous to Table 10. It is notable that topics represented by many indicators, such as institutions or trade intensity and composition, indeed drop in importance when reduced to 2 dimensions. In the reduced

[37] Signified by a negative sign in the %ΔMSE column under 'Exclusion' in Table 10.

[38] Things would be easier taking just the first principal component for each topic and fitting a single model, but as Appendix Table A15 shows, for some topics like Climate and Agriculture, the first PC accounts for less than 50% of the variance spanned by those predictors.

dataset, financial sector characteristics, production shares, institutions, and financial and aid flows are the most important dimensions affecting real growth volatility.

In terms of potential policy implications, the results suggest that the depth and resilience of the financial sector, the management of capital flows (esp. remittances), and improvements in the quality of institutions and the business environment are the factors most amenable to policy with a high impact on long term growth stability in Africa.

The entire exercise is repeated with CPI inflation, Figure 7 and Table 11 report the results with all indicators, and Table A17 with PC12. It is evident that for inflation stability a slightly different set of factors becomes very important. Exchange rate pass-through plays a dominant role in many African economies, followed by indicators of fragility and conflict, and institutions.

Figure 7: RF Predicting the MAD of CPI Inflation of 49 African Economies in 1990-2019

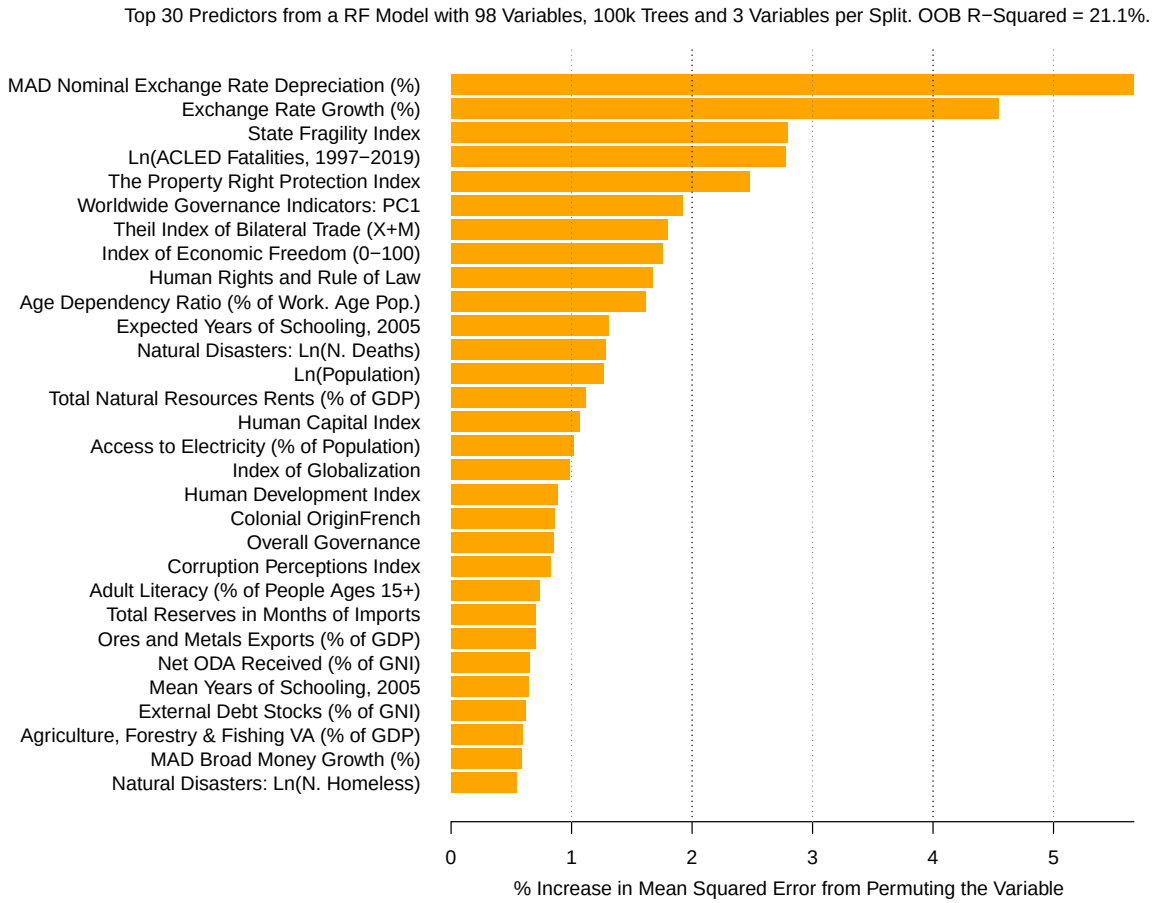


Table 11 shows that the exclusion of exchange rate variables worsens the model fit by 17.6%, whereas the exclusion of most other predictor groups increases the fit of the model by 1-3%. Apart from the exchange rate, conflict/fragility and institutions are important predictors of inflation volatility, followed by business conditions, population dynamics, trade intensity, trade diversification, and

the financial sector.

Table 11: RF Ranking of Indicator Topics: Predicting MAD CPI Inflation, 1990-2019

Method:	Permutation		Exclusion		Residual Fit		Combined
Topic	%ΔMSE	Rank	%ΔMSE	Rank	%ΔMSE	Rank	Avg. Rank
Exchange Rate and ToT	86.54	1	17.56	1	45.13	1	1.00
Natural Disasters & Conflict	72.25	2	5.16	2	32.71	2	2.00
Institutions	63.26	3	0.72	5	25.78	5	4.33
Business Environment	58.39	4	1.04	4	19.61	8	5.33
Population	44.53	5	-1.23	8	31.67	3	5.33
Trade Intensity and Composition	43.54	6	-2.22	13	29.10	4	7.67
Trade Diversification	38.31	9	1.20	3	-4.44	16	9.33
Financial Sector	43.36	7	-4.69	19	19.74	6	10.67
Education	12.74	17	-0.91	6	17.57	9	10.67
Geography & Accessibility	33.51	10	-1.43	10	16.25	12	10.67
Others	38.37	8	-2.75	18	19.68	7	11.00
Poverty & Inequality	23.94	13	-2.31	15	16.40	10	12.67
Health	20.53	15	-2.31	14	16.37	11	13.33
Natural Resources	18.40	16	-1.57	11	12.33	13	13.33
Debt & Reserves	26.00	12	-1.98	12	-13.25	18	14.00
Religion & Ethnicity	12.42	18	-1.39	9	-1.98	15	14.00
Production Shares	9.84	19	-0.97	7	-5.80	17	14.33
Financial & Aid Flows	22.82	14	-2.72	17	6.88	14	15.00
Climate & Agriculture	26.20	11	-2.51	16	-16.88	19	15.33

Exempting trade, which decreases in importance, this ranking is preserved when considering principal components in Table A17.

5.2 Time-Variation in Structural Factors

The comparison of changes in these factors with the documented changes in volatility over the 1990-2019 period is of great importance, but also very challenging as many indicators are either time-invariant, show little variation over time, or lack historical data to trace them back to 1990. The latter is particularly the case for survey-based variables measuring the quality of the business environment and financial access. Figure A30 shows some institutional and business variables over the time period, indicating no positive change in the Worldwide Governance Indicators, but significant improvements in business conditions and economic institutions in the recent years since measures became available. Restricting the analysis to variables with the necessary history thus provides an incomplete perspective of changes within African economies in the past 30 years.

Of the 98 variables considered in the cross-section, 70 have some time variation to be considered for analysis of changes[39]. Not included are mainly geography, religion, and ethnicity variables, static agricultural characteristics, and some institutions and business indicators with low time coverage.

[39]The first column in Table A12 in the appendix shows which variables are included in the panel.

The analysis is then repeated on a cross-section of first-differences for 49 African economies, obtained by subtracting the median of the 70 indicators over the 1990-2004 period from the 2005-2019 median, and relating this to the difference in the MADs of PCGDP growth and CPI inflation. Figure A31 and Table A13 show the results for PCGDP growth. It turns out that predicting changes in macroeconomic volatility over time is very challenging, the RF model reported in Figure A31 only explains 2.2% (OOB, the in-sample fit is higher) of the variance in the change of the MAD of GDP per capita growth between 1990 and 2019. With some hyperparameter tuning the OOB R^2 can be increased to 4%, but this is still not satisfactory. It is nevertheless noteworthy that 2 financial sector variables are among the top 5 predictors that increase the MSE by more than 1%. The other 3 variables are GDP per person employed, life expectancy and population, which proxy for changes in the labour force and in human capital. Table A13 confirms the importance of the financial sector as well as social characteristics such as population dynamics, health, and education, alongside institutions and 'Others' which includes GDP per person employed, gross national savings, and the Human Development Index. The analysis with PC12 in Table A19 is broadly consistent with these results, and additionally emphasizes developments in the exchange rate and ToT.

Overall, however, the result is a negative one, as the model does not explain much variation in changes in growth volatility. This could be due to some statistical issues incurred by relating changes in the medians to changes in the MAD of volatility, which throws away a lot of potentially useful variation, but, as shown in the Online Appendix, employing less robust measures such as the standard deviation of growth and time-averages of predictors, does not produce models with higher predictive power. Thus the results also strongly suggest that the bulk of the African moderation in growth volatility is not due to changes in hard structural factors like institutions, trade intensity, and diversification, conflict intensity, poverty and inequality, or natural resource rents, which make up the bulk of the predictor space, and thus the variables randomly chosen at each split to build a predictive model. These factors continue to be important in explaining different levels of baseline volatility between African countries (as shown above), but they do not explain the African moderation.

Analogous results for Inflation are provided in Figure A32 and Tables A14 and A20. The reduction in exchange rate volatility (Figure A23) is the strongest correlate of inflation moderation in Africa, followed, with some distance, changes in population, external debt, institutions, and natural disaster and conflict incidence. With an OOB R^2 of 2.8%, the overall the result is also negative: apart from exchange rate management, changes in inflation volatility are not easily predictable from changes in the structural characteristics of African economies.

These results are broadly robust against alternative choices of outcome variables. Robustness checks using the standard deviation and IQR of per-capita growth and inflation, and alternative per-capita growth and inflation series from the World Bank, are provided in an Online Appendix.

6 Summary and Conclusion

Macroeconomic data for the past 30 years (1990-2019) show a large, broad-based, and persistent improvement in macroeconomic conditions in African economies, characterized by less volatile real per capita growth and CPI inflation rates, alongside higher average growth and lower inflation levels. The improvement in macroeconomic conditions is such that, apart from inflation, where the ROW median was at ∼2% in 2010-2019 vs ∼4% in Africa, the median African country has caught up with ROW. The bulk of this "Great African Moderation" has taken place between 1995 and 2012, during which macroeconomic conditions improved ∼2 times more rapidly in Africa than in ROW. A particularly large stabilization occurred in African LICs. Disaggregated analysis at the country and sector level reveals that the majority of countries have experienced large declines in the volatility of agricultural VA, and sizeable declines in the volatility of services VA. In parallel, there were more heterogeneous developments in the industrial sector, where several countries like Ghana or Tunisia incurred increases in volatility.

At the regional level, Eastern and Northern Africa experienced the greatest decline in agricultural volatility, while North Africa experienced concurrent increases in industry and services volatility. Western and Southern Africa experienced smaller improvements in agriculture and services stability, but both also incurred slight increases in industrial volatility. Overall, the Eastern Africa region shows the most remarkable macroeconomic stabilization, and replaces Nothern Africa as the most macroeconomically stable region in Africa.

Sectoral decompositions of the change in aggregate per-capita growth volatility, show that 60-70% is accounted for by changes in the volatility of agriculture and services VA, and around 30% can be explained by changes in the covariance structure of production, with all 3 broad sectors becoming more independent/less complimentary to each other. The remaining ∼5-10% are comprised of a pure structural change effect of up to 5% - caused by VA shifting to the less volatile service sector - and by a small reduction in the volatility of industrial VA. Overall the contribution of Agriculture to aggregate moderation outweighs the economic size of the sector in most countries. On the consumption side, the bulk of stabilization is accounted for by smaller consumption and investment volatility.

In light of these findings, the second part of this paper investigated the correlation of changes in the external environment, financial deepening, domestic macroeconomic policies, and structural and institutional factors, to the African moderation. The results suggest that growth and moderation in Africa were likely benefited by lower levels of domestic and external debt, higher FDI and remittance inflows, and improved terms of trade. Externally induced volatility such as volatility of the exchange rate, terms of trade, the merchanside trade balance, FDI, and remittances also decreased over the period. A gradual deepening of the financial sector, as evidenced by higher levels of reserves held by the central bank as well as by commercial banks, more domestic credit to the private sector and

broad money as a share of GDP, and an increase of gross national savings by 4-5% of GDP, likely also played an important role.

Regarding macroeconomic policies, there was a gradual aggregate shift in exchange rate management over the period, with several countries abandoning free floats, crawling bands, and dual market bindings in favor of a crawling peg, which contributed to exchange rate stability, inflation stabilization, and, to a lesser extent, growth stabilization. Macroprudential policy was also found to be a potentially very effective tool in bringing down macroeconomic volatility, but, except within certain financial markets such as bonds and commercial credits, cross-country data show no aggregate trend in macroprudential stringency in Africa since 1998. Another important development affecting macroeconomic conditions in Africa was the adoption of fiscal rules by a large number of African countries from 1997 onwards. The adoption of fiscal rules, particularly budget-balance and debt rules, has a large and statistically significant negative relationship with growth and inflation volatility.

Examining a broad set of structural characteristic including institutions and business conditions, the structure of production and trade, geography and agriculture, population, health, education, conflict and disasters, natural resources, religion, ethnicity, poverty and inequality, as well as semi-structural factors such as the intensity of financial flows, financial depth, debt levels, exchange rates and terms of trade, shows that these factors can explain around 30% of the cross-sectional variation of growth volatility between African countries in 1990-2019. The quality of institutions appears to be the most important factor affecting structural per-capita growth volatility, followed by the intensity of financial flows, the characteristics of the financial sector, trade intensity and composition. The business environment, natural resource extraction, and disaster and conflict incidence were also found to be important. Inflation volatility on the other hand is heavily influenced by exchange rate volatility, followed by conflict and the institutional and business environment. This indicates that stabilizing the exchange rate, managing conflict, and maintaining a strong institutional environment is key to keeping inflation low in Africa in the medium term.

The prediction of differences in volatility over the period with changes in these factors yields that most of the moderation cannot be predicted. The results nevertheless indicate the importance of financial depth and human capital development for growth stabilization, and of exchange rate management for inflation stabilization.

Thus overall the paper succeeds to a greater extent in showing what did not cause the African Moderation, that is, it was not, at large, a byproduct of classical structural change, not caused by reduced volatility in the industrial sector (e.g. via improved inventory management), or by monetary policy shifting to inflation targeting, and also not heavily influenced by other changes in economic structure, diversification, conflict incidence, or institutions. On the positive side, the results provide evidence for a role of changes in the external environment faced by African economies, greater

resilience of the financial sector, and macroeconomic policy, particularly exchange rate and fiscal management. Analysis also suggests that improvements in human capital and the business environment played a role, but the evidence presented in this paper is rather week.

These findings provide a basis for further research that investigates in more detail the causes and consequences of macroeconomic moderation in Africa, and the role of policy for macroeconomic stabilization. Further significant changes in policies or institutions may have taken place that are not easily measurable. For example, central banks might have become much better over time at targeting macroeconomic aggregates or implementing macroprudential policies. The role of global factors such as US monetary policy, global financial markets, and commodity price volatility for African moderation could also be investigated in more detail. It is also not clear in which ways improvements in the business environment, as evident in the Doing Business Rankings for Africa and the Logistics Performance Index, interact with broader macroeconomic stabilization and domestic financial deepening.

Looking forward, Africa and the World face large uncertainty regarding growth and inflation. The WEO October 2022 predicts lower growth in SSA of 3.6% in 2022 and 3.7% in 2023, down from 4.7% in 2021, and also high CPI inflation of 14.4% in 2022 and 11.9% in 2023, up from 11.1% in 2021. Furthermore, as documented by Atingi-Ego et al. (2021) and others, with median debt to GDP ratio in Africa $\sim$70%, and $\sim$50% of SSA economies classified as in debt distress or at high risk of debt distress, as well as rising interest rates and sovereign spreads throughout 2022, fiscal sectors in Africa are under considerable pressure. Accelerating processes of regional and fiancial integration, including the implementation of AfCFTA, also add to the uncertainty regarding Africa's future macroeconomic environment. On the face of it, the results of this paper have little to say about how well these forces will be managed by African economies over the coming years. However, if this paper correctly pointed at some of the factors underlying Africa's macroeconomic moderation, then it is unlikely that macroeconomic volatility in Africa will ever revert to the levels of past (pre-millenial) decades. The forces of structural change, domestic financial deepening, improvements in macroeconomic policy (particularly monetary/exchange rate), and in human capital, are here to stay and advance further, with beneficial effects for future macroeconomic stability in Africa. At last, it does not do any harm to mention that the great moderation experienced earlier by many advanced and emerging economies still shows little signs of reversal, inspite of higher inflation levels and mounting fiscal pressures.

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Appendix

The Appendix consists of 3 parts. Part 1 provides a spectral analysis to examine the qualities of the volatility of the growth rate of a GDP per capita as a proxy for adverse economic volatility. Part 2 provides additional tables and figures referred to in the main text of the paper. Part 3 is available online and provides robustness checks for the machine learning analysis of structural factors in section 5, using alternative outcome measures.

Spectral Analysis

As noted by Gelb (1979), many measures of instability used in economic literature are arbitrary and emphasize volatility at certain frequencies without rigorous justification. Shumway et al. (2000) show that first-differencing amounts to a high-pass filter that gives most weight to volatility at frequencies of 2 years and gradually down weights volatility at lower frequencies. Gelb (1979) suggests to consider the full frequency spectrum and to devise a weighting scheme emphasizing the relative importance of certain frequencies above others to generate an indicator. This Idea is formalized by Tsui (1988), who also shows that various common trend-cycle estimates (including first-differences) can be regarded as special cases of a weighting function $f(\omega)$ applied to the spectral density. This analysis follows Tsui (1988), and proposes a weighting function based on the empirical relationship of volatility at different frequencies with average growth rates.

In a first step, the spectral density of fluctuations needs to be computed for all country GDP per Capita series are shown in Figure A6. Gelb (1979) notes that in the presence of strong trends, spectral density estimates on the raw series are often highly misleading because no periodic component fits the trend well, so variance from this very low-frequency phenomenon (the trend) "spills over" onto higher frequency components. Therefore all country series are first detrended using a linear trend on the log-level series, i.e. we consider all variation that lets countries depart from growing at a constant rate in per-capita terms. The spectral density can be approximated by the periodogram given by

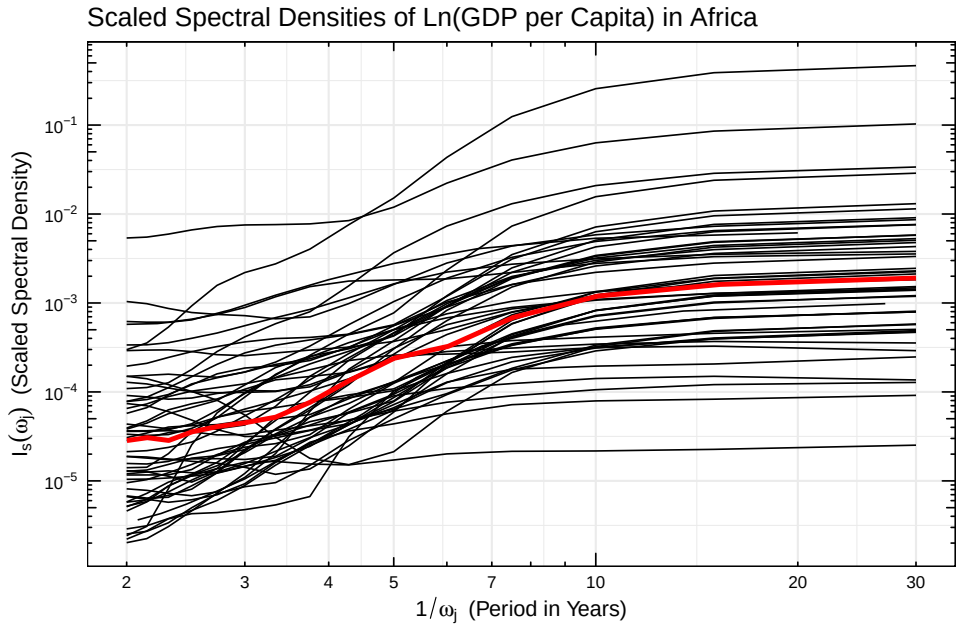
$$I(\omega_j) = |d(\omega_j)|^2 \qquad \text{where} \qquad d(\omega_j) = \frac{1}{\sqrt{n}} \sum_{t=1}^{n} x_t e^{-2\pi i \omega_j t} \tag{6}$$

is the complex-valued coefficient of the Discrete Fourier Transform at fundamental frequency $\omega_j = j/n$ for $j \in 0, \ldots, n-1$ of the series x_t observed for n periods. To aid interpretation we consider the scaled periodogram $I_s(\omega_j) = \frac{4}{n} I(\omega_j)$, such that the sum of the periodogram ordinates over all frequencies $\sum_{\omega_j} I_s(\omega_j)$ equals the squared amplitude of the signal x_t, and furthermore $\sum_{\omega_j} I_s(\omega_j) = 2\ var(x_t)$, such that the power of the scaled periodogram at each frequency ω can be considered as twice the contribution of that frequency to the overall variance of x_t[40]. A further issue is that the periodogram is not a consistent estimator of the spectral density. A frequently employed solution is

[40] It is a property of sine and cosine waves that the squared amplitude equals twice the variance. For details see Shumway et al. (2000).

smoothing the periodogram with Daniell smoothers to produce more consistent estimates. Another technique to improve the periodogram as a spectral estimator is tapering, which reduces the effect of frequencies outside the estimated interval. To reach consistent spectral estimates at the country-level, I apply a consine bell taper of 15%, and smooth the periodogram with two modified daniell smoothers of with 3 and 7 (period-years), which are convolved to produce the final spectral estimates. The scaled densities thus estimated for all countries are shown in Figure A1, where the red line denotes the median across all country-spectra.

Figure A1: Estimated Country Spectral Densities and Median Spectral Density



Data Source: IMF World Economic Outlook, October 2021

It is evident that the spectra of different countries are quite heterogeneous, with about 3 orders of magnitude lying between the least and most-volatile countries at each frequency, but an overall decrease in spectral power with higher frequencies is common to all countries. The median estimate in Figure A1 shows that on average volatility at low frequencies with periods of 20-years+ is around 2 orders of magnitude larger than year-to-year changes in output (2-year period).

To determine whether volatility at certain frequencies is harmful for growth in African economies, I compute the cross-sectional correlation of the spectral density with median GDP per capita growth in the 1990-2019 period, for each fundamental frequency ω_j. Figure A2 reports these correlations in the top half, and the bottom half shows corresponding regression coefficients, which also take into account the differing magnitudes of volatility at different frequencies that Figure A1 made evident.

Figure A2: Correlation of Spectral Density and Median Per-Capita Growth, Africa 1990-2019

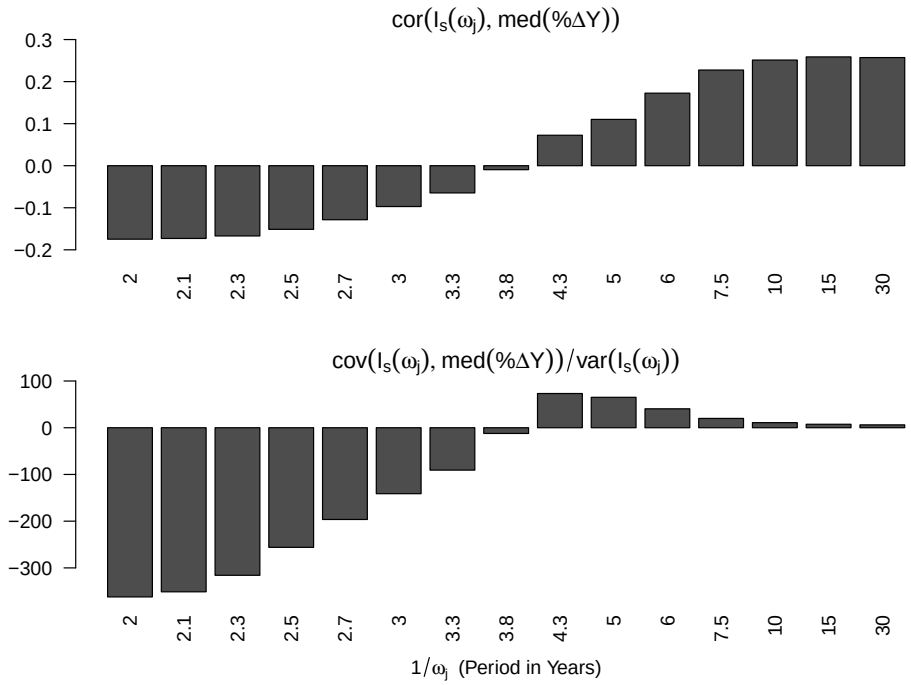


Figure A2 exhibits an astonishing clear pattern, with a strong negative correlation of about -0.2 between economic growth and volatility at high frequencies of 0.5 (period 2 years), which then gradually tends to zero at frequencies of 0.25 (period 4 years), and turns positive up to about 0.3 for lower frequency variation with 10 to 30-year periods. Thus African data indeed show that short-term volatility with periods of up to 4 years is associated with lower growth, whereas volatility at longer periods is an indication of healthy growth.

This suggests that a high-pass filter like computing the growth rate might do reasonably well to extract fluctuations harmful for growth. I use the regression coefficients in the bottom half of Figure A2 to create an optimal discrete high-pass filter $f(\omega_j)$ in the spirit of Tsui (1988), that capturing volatility harmful for growth. The filter simply consists of the absolute values of all negative regression coefficents on the frequency bands, setting positive coefficients to zero. Multiplying the spectral density estimate for each country with this filter and summing up the weighted spectral ordinates gives the power of the filtered spectrum, which provides a summary statistic of the harmful volatility in each country. Formally, I define a harmful volatility index (HVI) as

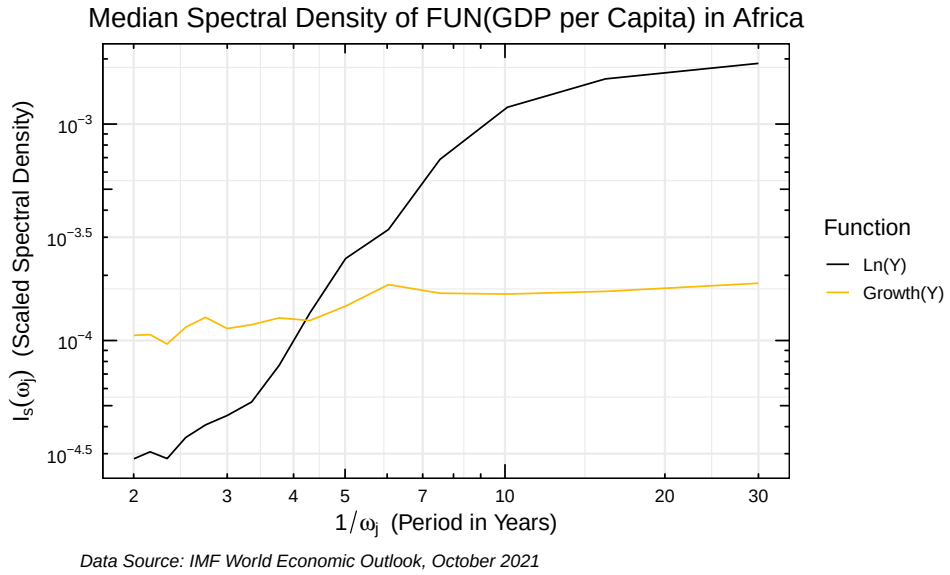
$$\text{HVI} = \sum_j f(\omega_j) \times I_s(\omega_j) \quad \text{where} \tag{7}$$

$$f(\omega_j) = -\beta_{\omega_j} \times 1[\beta_{\omega_j} < 0] \quad \text{and} \tag{8}$$

$$\beta_{\omega_j} = \frac{cov(I_s(\omega_j), med(\%\Delta Y))}{var(I_s(\omega_j))}. \tag{9}$$

Before comparing the HVI to some statistic computed on the growth rate, I wish to determine to what extent computing a growth rate itself resembles the transformation induced by applying $f(\omega_j)$ to the data. Figure A3 shows that computing the growth rate indeed works like a high-pass filter that, relative to the natural log baseline, accentuates volatility at periods lower than 4.2 years and dampens volatility at higher periods.

Figure A3: Spectral Densities of Growth Rate and Natural Log of GDP per Capita



Data Source: IMF World Economic Outlook, October 2021

Dividing the growth-spectrum by the log-spectrum yields the discrete filter that, if multiplied with the log-spectrum, yields the same effect as computing a growth rate (i.e. differencing the log-level series) in the time domain. I call this derived first-difference filter $f^{\Delta}(\omega_j)$. To compare $f^{\Delta}(\omega_j)$ to the optimal empirical filter $f(\omega_j)$ based on regressions against median per capita growth, I scale both filters so that the weights/coefficients on all frequencies ω_j sum to 1. Figure A4 shows the outcome.

Figure A4: First-Difference Filter and Regression-Based Filter

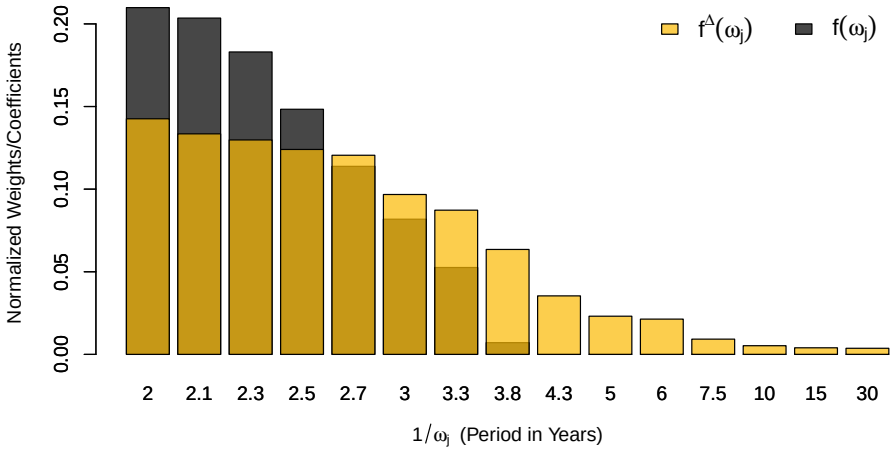
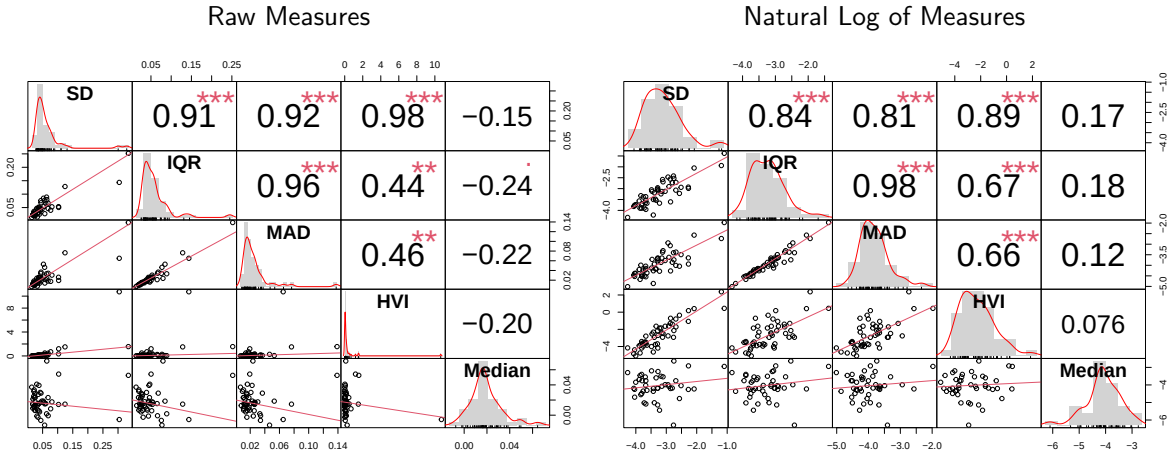


Figure A4 indicates that the first-difference filter $f^{\Delta}(\omega_j)$ broadly resembles the optimal empirical filter $f(\omega_j)$ for extracting volatility harmful to growth. Compared to the latter, first-differencing provides a smoother transformation of the data, that puts less weight on high-frequency volatility, but therefore keeps some of the low-frequency volatility as well. Since finding an optimal filter $f(\omega_j)$ to extract harmful economic volatility is likely always going to be a complex empirical task, and the resulting filter is prone to be highly dependent on the data and methodology used to estimate it, a simpler methodology such as computing first-differences and then applying some statistic to summarise the volatility in the differenced series is preferable to ensure the transparency and reproducibility of research. Below I consider the 3 summary statistics used in this paper: the standard deviation (SD), interquartile range (IQR) and median absolute deviation (MAD) of the growth rate of GDP per capita, and compare them to the HVI index (Eq. 7) and median per capita growth, computed for each African country using data from 1990 through 2019. The data are the correlated, and a regression line is fit, using a robust MM estimator following following Yohai (1987) and Koller and Stahel (2011), with a high breakdown point of 0.5, ensuring that outliers don't influence the estimates. Figure A5 shows charts including these robust fits, a robust correlation coefficient derived from the fit, and empirical volatility distributions estimated by a histogram and a gaussian kernel density.

Figure A5: Volatility Measures and Median GDP per Capita of 51 African Economies, 1990-2019



The left side of Figure A5 shows that the HVI is positively correlated with all 3 volatility measures derived from the growth rate, particularly with the SD. All volatility measures are also negatively correlated with the median growth rate. Since a few countries such as Lybia, Guinea-Bissau, Eritrea and Rwanda have very high levels of volatility (due to conflicts during this period), the empirical volatility distributions are right-skewed. As indicated on the left side, the negative correlation of the IQR and MAD of growth with median growth are stronger compared to the HVI and the SD, which may be the effect of outliers having a stronger effect on the SD and HVI[41]. The right side of Figure

[41] The fast fourier transform underlying the smooth spectral estimates used to produce the HVI is not robust against outliers.

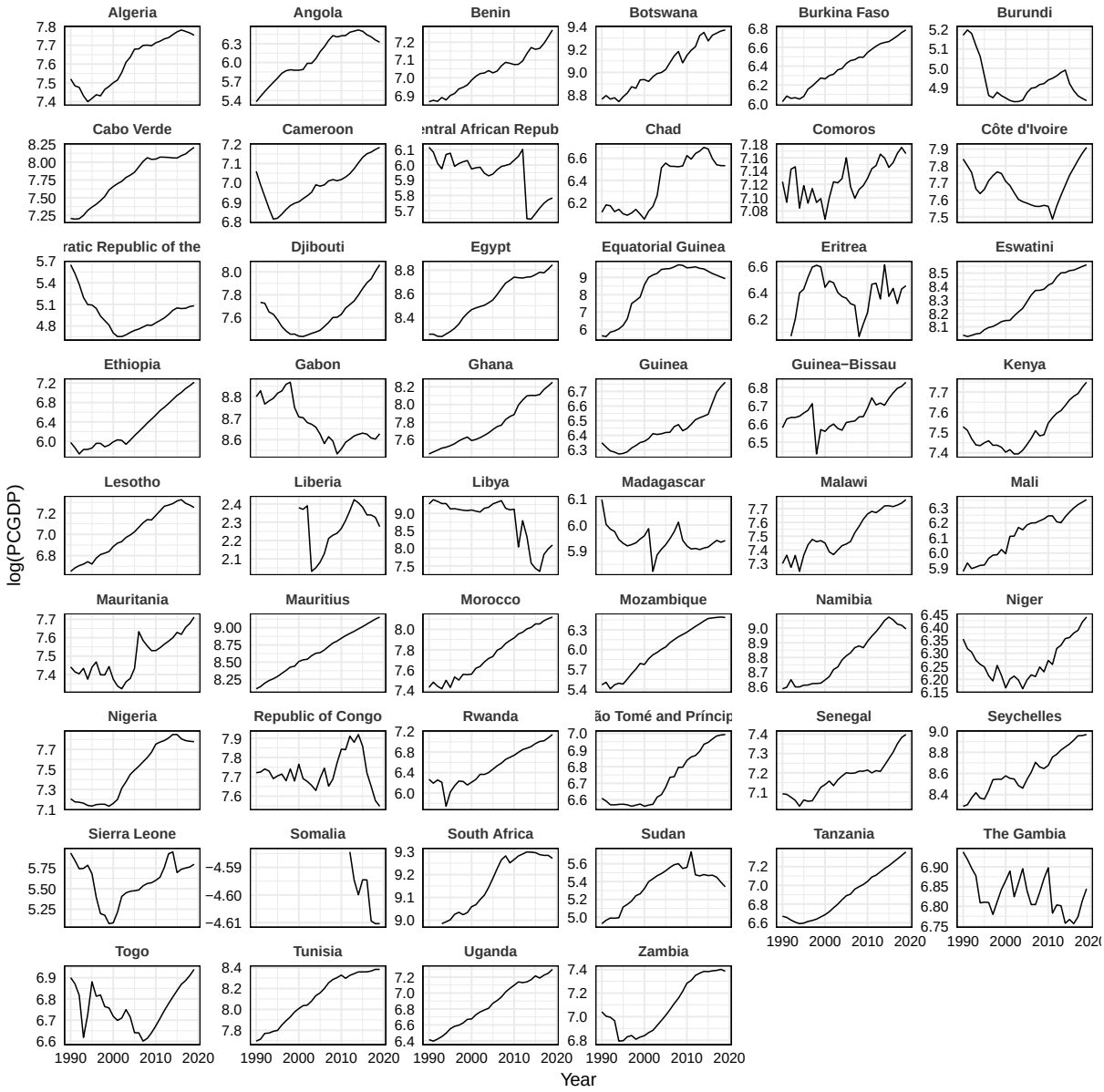
A5 therefore also shows a version of the chart where the natural log was applied to all measures. This gives nicer scatterplots and density estimates, but also lets the relationship between volatility and median growth turn positive (albeit insigificant), for all measures apart from the HVI where the correlation in zero. This change in the sign of correlations is explicable as some of the countries affected by conflict in 1990-2019, such as Rwanda and Guinea-Bissau, also experienced high average growth throughout this period, and may exert stronger influence on the MM estimates after taking the log.

To conclude, the discussions in this section highlighted that when dealing with a difficult to measure phenomenon such as economic volatility, three things are important: precise measurement of (harmful) volatility, robustness against outliers, and a simple, reproducible, and data-independent methodology. This paper endorsed robust statistics such as the IQR and the MAD, computed on the growth rate of the series, to measure economic volatility. The analysis conducted in this section shows that computing the growth rate provides a decent approximation to an optimal empirical filter, applied to the spectral density to extract volatility harmful for economic development in Africa, and that computing the IQR or MAD of the growth rate provides an acceptable and robust summary measure of this volatility, comparable to the power of the optimally filtered spectrum (the HVI). The IQR and MAD of the growth rate thus sufficiently meet the joint aims of precision, robustness and simplicity. At the country-level, the MAD is preferred to the IQR as it is more robust.

Additional Tables and Figures

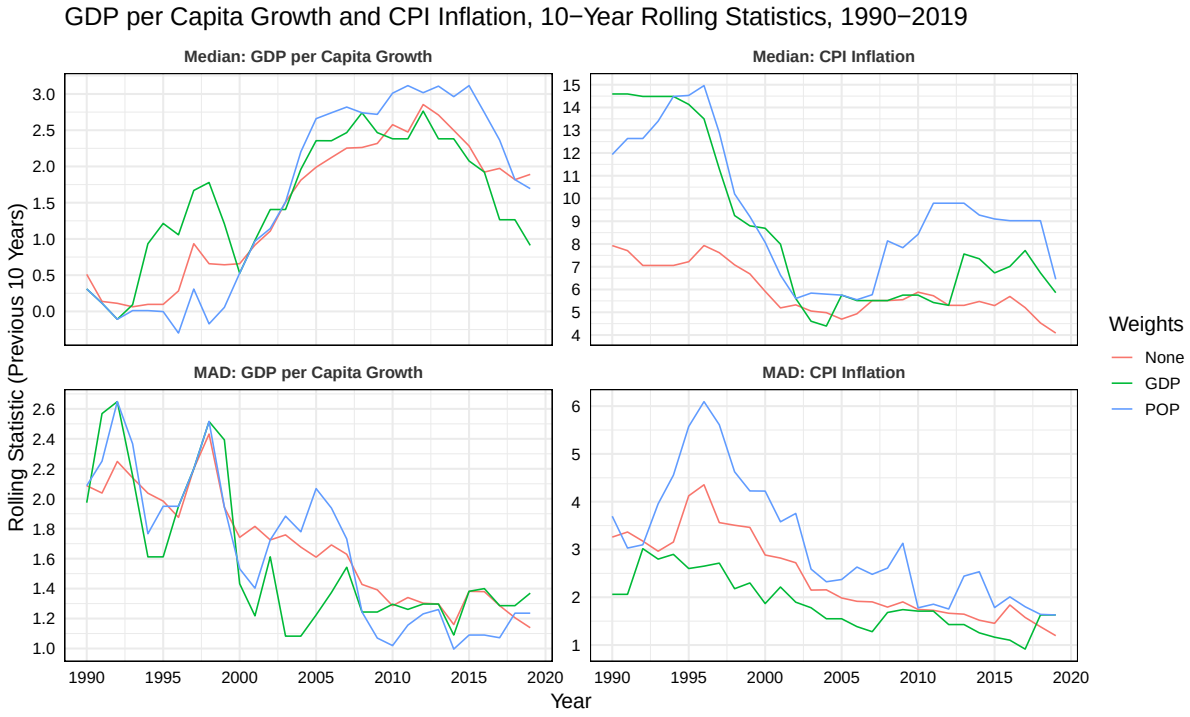
Section 2: Aggregate Relationships and Trends

Figure A6: Log GDP per Capita for 52 African Economies in Constant 2010 USD, 1990-2019



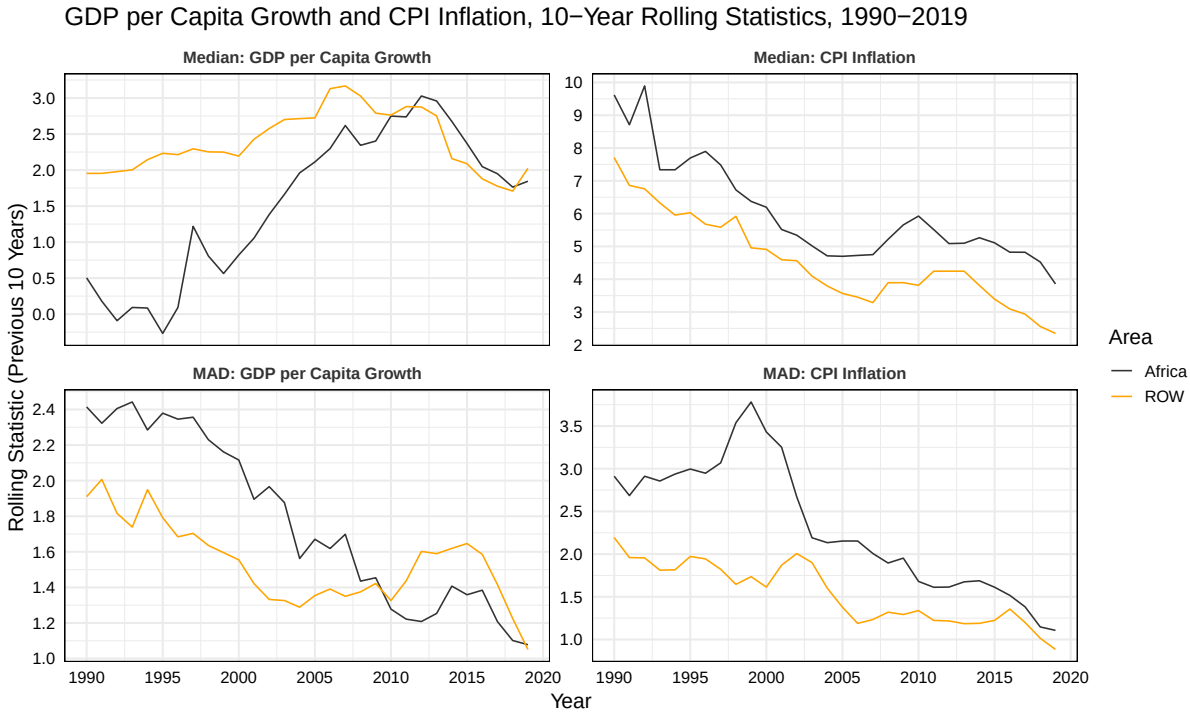
Data Source: IMF WEO October 2021 and IFS

Figure A7: Volatility in Africa Over Time



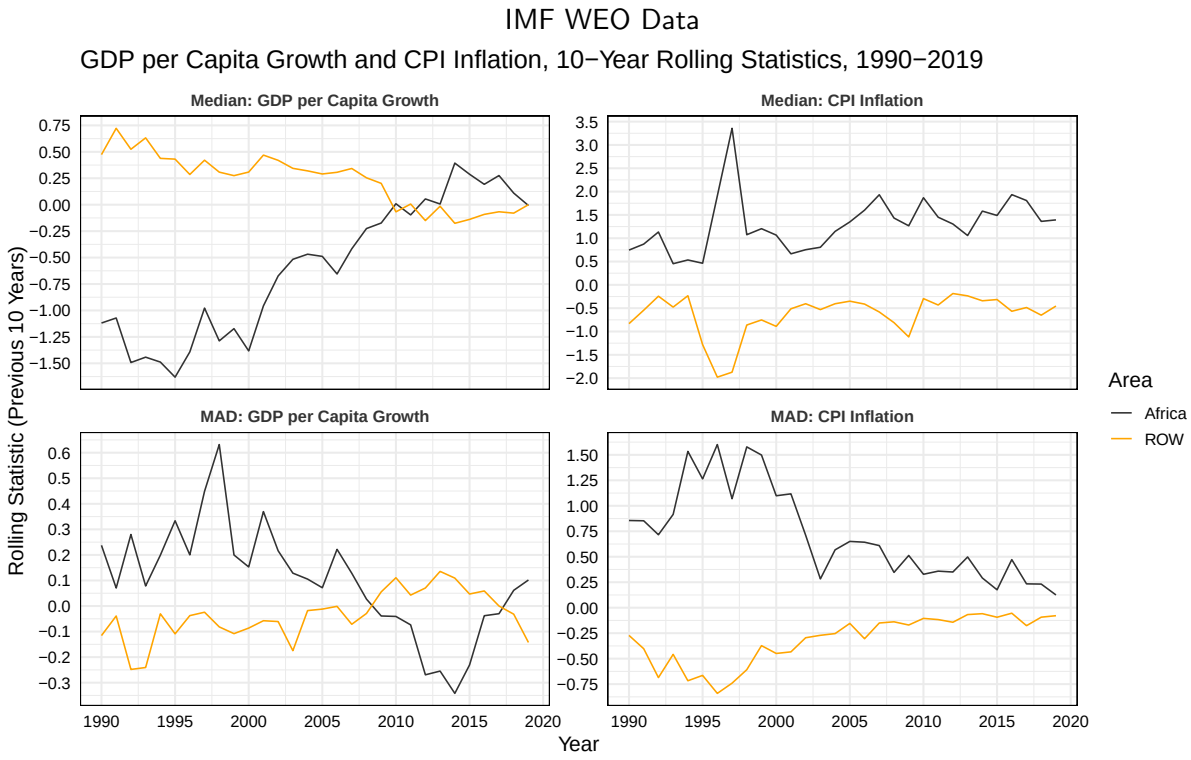
Data Source: IMF World Economic Outlook, October 2021

Figure A8: Figure 1 with World Bank WDI Data

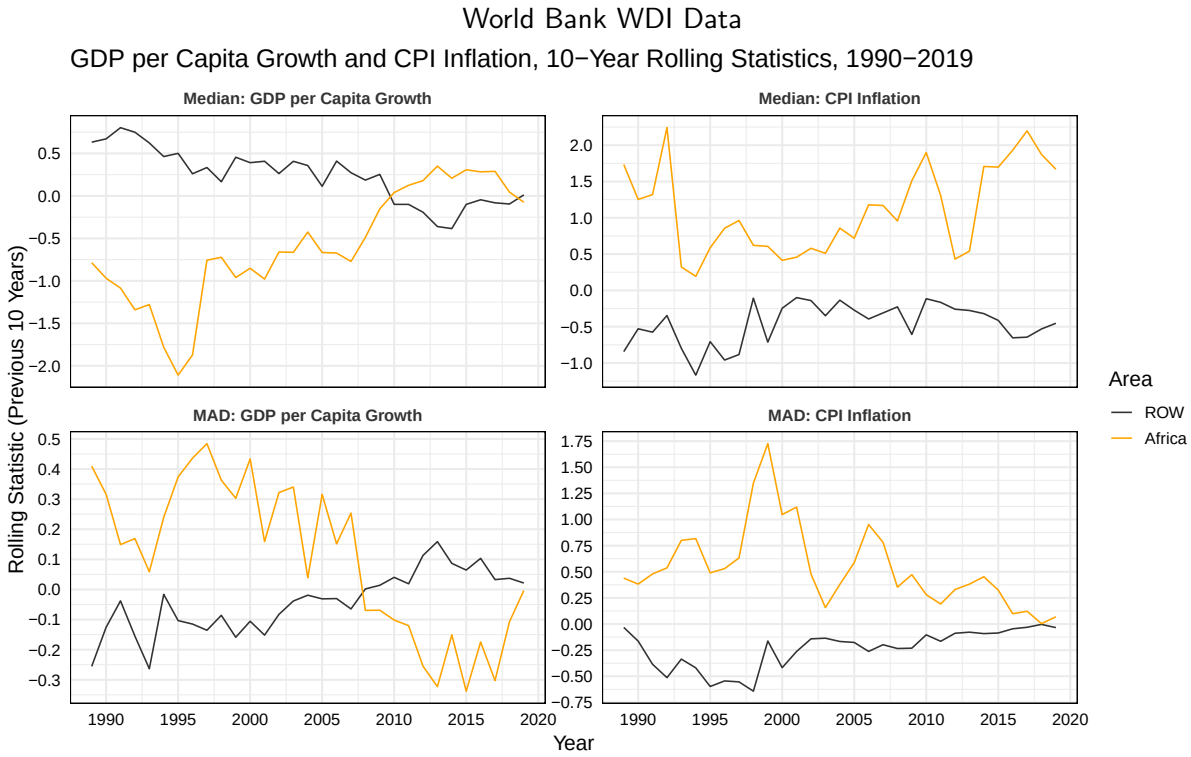


Data Source: World Development Indicators, Accessed November 2021

Figure A9: Figure 1 with Time-Medians Subtracted from Rolling Statistics

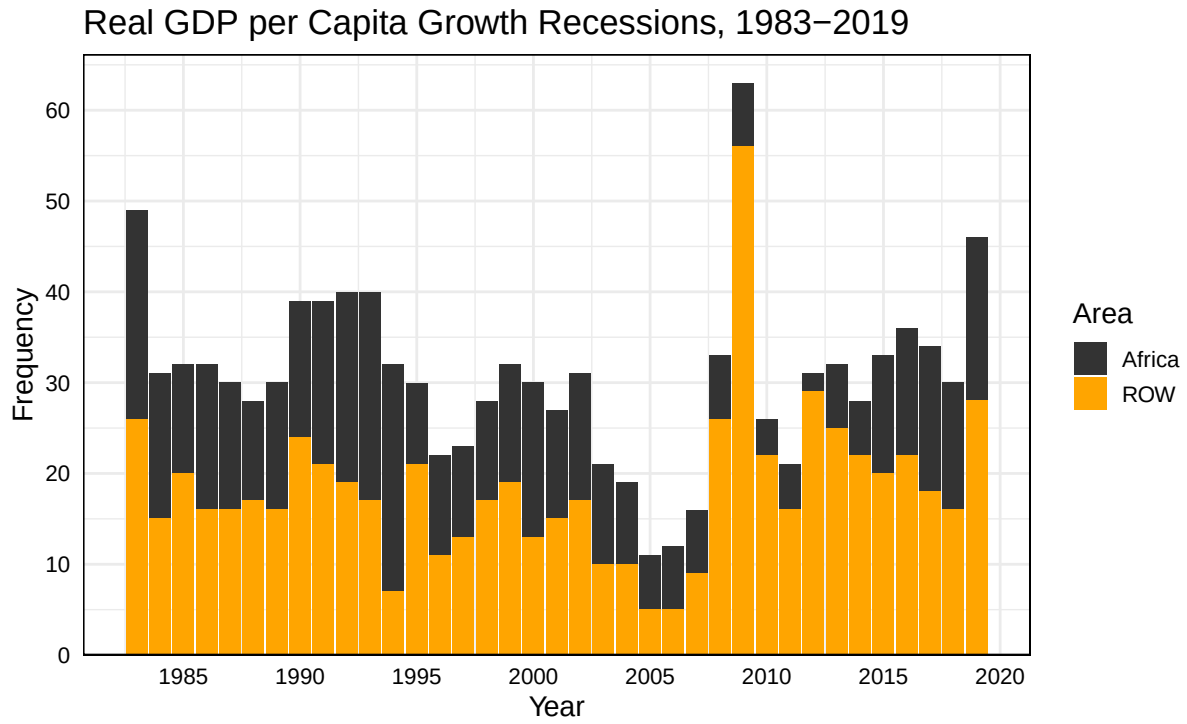


Data Source: IMF World Economic Outlook, October 2021



Source: World Development Indicators, 2021

Figure A10: Growth Recessions Following Syed et al. (2017)



Data Source: IMF World Economic Outlook, October 2021

Figure A11: AR1 Analysis a la Blanchard and Simon (2001) with World Bank Data

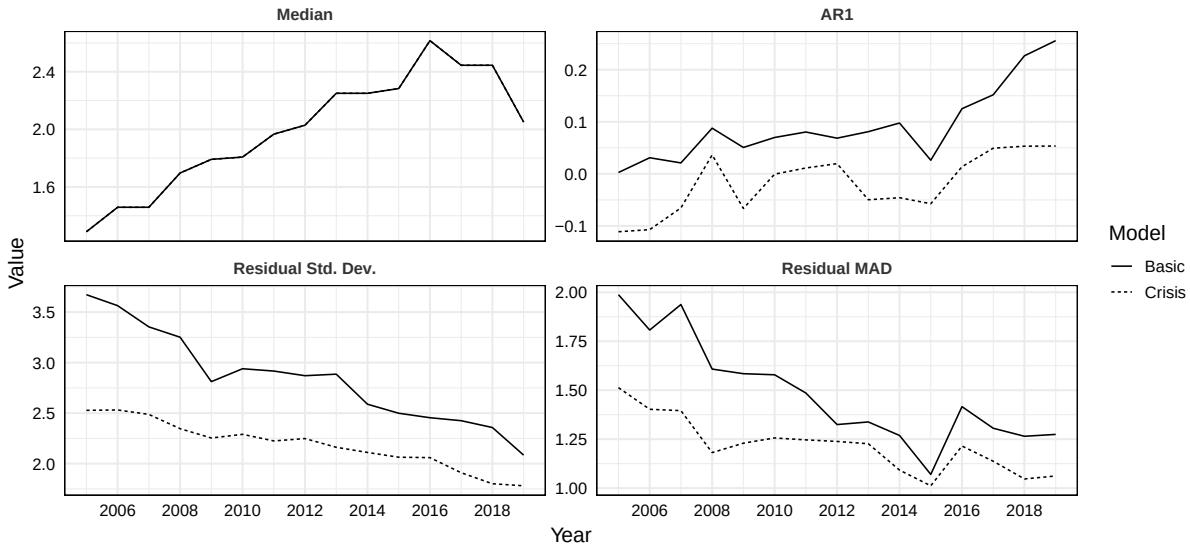
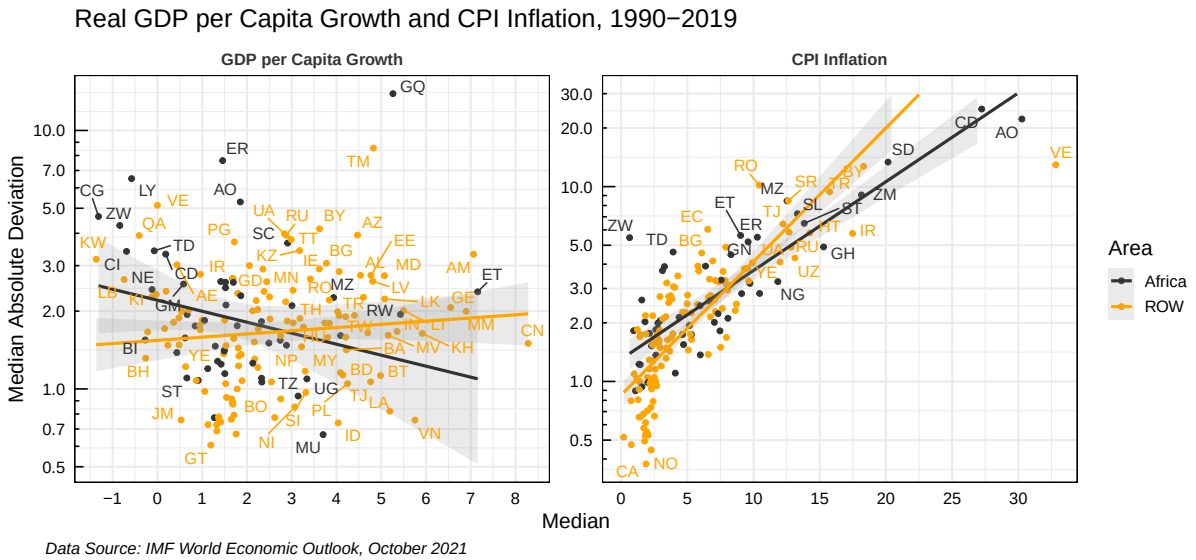


Table A1: Real Per Capita Growth and Inflation Performance in Africa, 1990-2019

Area		Per Capita Growth			Inflation		
	N	Median	MAD	IQR	Median	MAD	IQR
Africa	**51**	**1.506**	**1.822**	**3.991**	**5.306**	**2.230**	**4.925**
Low income	21	1.457	1.942	4.382	6.374	3.312	7.907
Lower middle income	21	1.521	1.609	3.601	4.715	2.010	3.880
Upper middle income	8	1.453	1.848	3.675	4.903	2.023	3.997
High income (SYC)	1	2.909	3.665	6.798	2.630	1.846	3.433
ROW	**124**	**2.370**	**1.724**	**3.532**	**3.549**	**1.754**	**4.318**
Low income	5	2.755	1.172	2.642	12.007	4.102	10.610
Lower middle income	24	2.985	1.654	3.085	6.996	2.733	5.856
Upper middle income	43	2.752	2.173	4.207	5.015	2.581	6.057
High income	52	1.758	1.616	3.178	2.285	1.024	2.112

Data Source: IMF WEO, October 2021. Real GDP per capita growth is calculated using the constant national currency series (NGDPRPC), and inflation is based on average national consumer price indices (PCPIPCH).
Notes: Statistics are calculated at the country-level, and aggregated across countries using the median. Countries with < 20 obs. for growth or inflation in 1990-2019 were excluded - in Africa Liberia, Somalia and South Sudan.

Figure A12: Empirical Relationship Between Levels and Volatilities



Data Source: IMF World Economic Outlook, October 2021

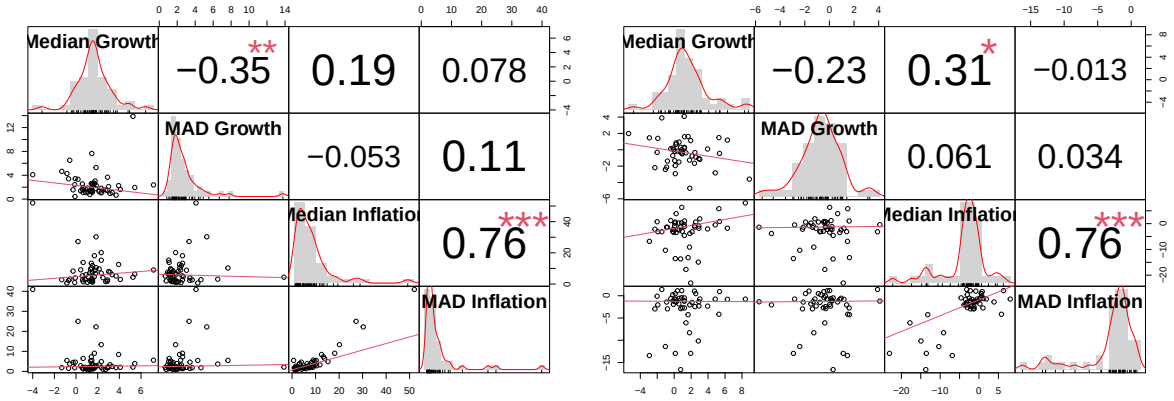
Table A2: Output and Inflation Volatility

Area	N	GDP/Capita β	GDP/Capita P($\beta \neq 0$)	GDP/Capita R^2	Inflation β	Inflation P($\beta \neq 0$)	Inflation R^2
Africa	**51**	**-0.187**	**0.035**	**0.083**	**0.375**	**<0.001**	**0.596**
Low income	21	-0.048	0.596	0.016	0.396	<0.001	0.608
Lower middle income	21	-0.569	0.002	0.389	0.252	<0.001	0.810
Upper middle income	8	-0.837	0.130	0.370	0.058	0.689	0.026
ROW	**124**	**0.043**	**0.322**	**0.008**	**0.361**	**<0.001**	**0.820**
Low income	5	-0.076	0.228	0.444	0.365	0.246	0.427
Lower middle income	24	-0.105	0.341	0.041	0.252	<0.001	0.632
Upper middle income	43	0.068	0.343	0.022	0.383	<0.001	0.800
High income	52	0.125	0.055	0.066	0.427	<0.001	0.478

Data Source: IMF WEO, October 2021. See also footnote to Table A1.
Note: A regression of the medians on the MADs of the country-series is run using a robust MM estimator following Koller and Stahel (2011). Available in R package *robustbase*.

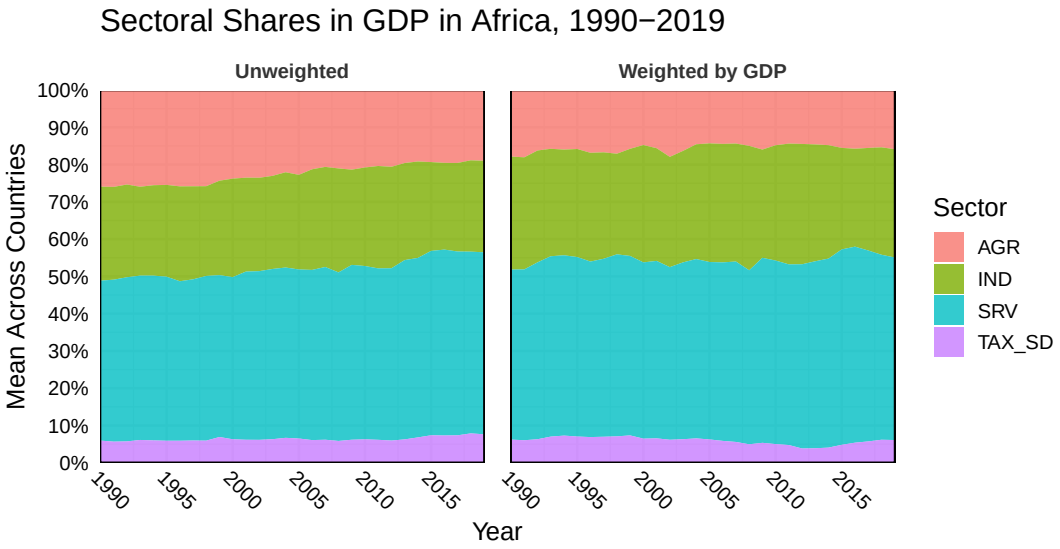
Figure A13: Empirical Relationship Between Levels and Volatilities in Africa

Whole Period: 1990-2019 *Half-Period Difference:* 2005-19 – 1990-04



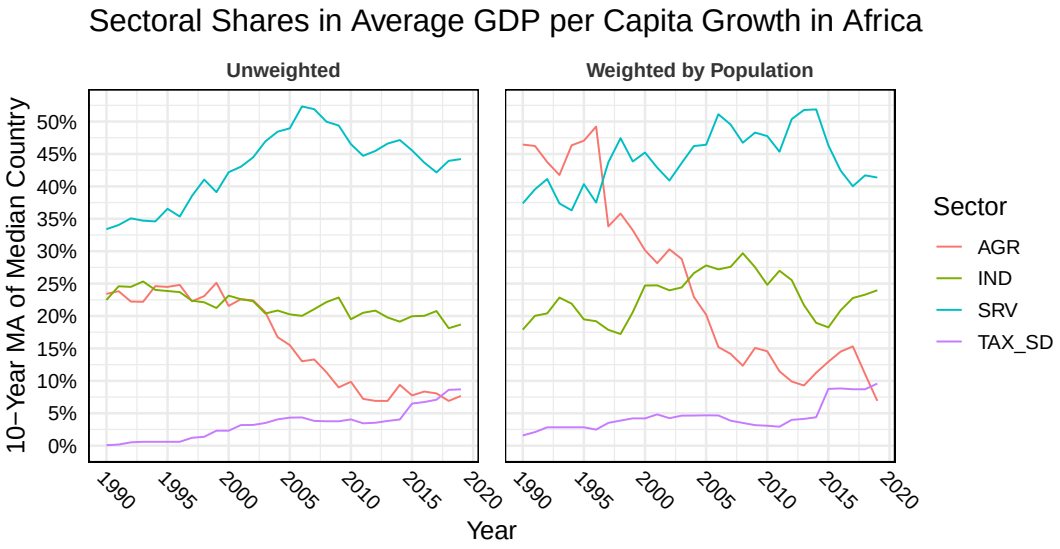
Section 3: Decompositions of Output and Volatility

Figure A14: Production side GDP Shares



Data Source: World Development Indicators, Accessed November 2021

Figure A15: Production side GDP Growth Shares



Data Source: World Development Indicators, Accessed November 2021

Table A3: Sectoral Volatility and Contribution to Aggregate Volatility, 1990-2019

Data	*Sector*:	AGR	IND	SRV	AGR	IND	SRV
Sector Share ($\bar{\theta}_k$):		0.236	0.279	0.485	0.231	0.279	0.487
	Covariance:	**Classical**			**Robust** (SDE)		
Sector	AGR	128.00			68.87		
Growth	IND	-13.76	117.86		-6.55	62.79	
(ΔVA/VA$_{t-1}$)	SRV	-1.32	-7.51	53.36	-0.79	-1.30	26.51
Sector	AGR	6.41			2.16		
Contribution	IND	-0.53	5.94		-0.31	2.93	
(ΔVA/GDP$_{t-1}$)	SRV	-0.16	-0.59	9.70	-0.05	-0.30	5.41

Notes: Since sectoral growth rates can be very volatile, I employ both a classical (Pearson) and robust covariance estimator with a high breakdown point (0.5) based on Stahel (1981) and Donoho (1982). The choice of methods was informed by Maronna et al. (2019) and available implementations in various R packages. The Stahel-Donoho robust covariance estimator is implemented by the package *rrcov* (Todorov and Filzmoser, 2009). Covariance terms are aggregated across countries using the median, whereas sectoral shares are aggregated with the mean. Average shares for each country are computed using all but the first observation following Eq. 3. The shares reported above "Robust" are computed by taking the median share for each country, and aggregating across countries using the mean.

Figure A16: Production side GDP Shares: ETD Data

Figure A17: Sector Volatility and Contribution to Aggregate Volatility

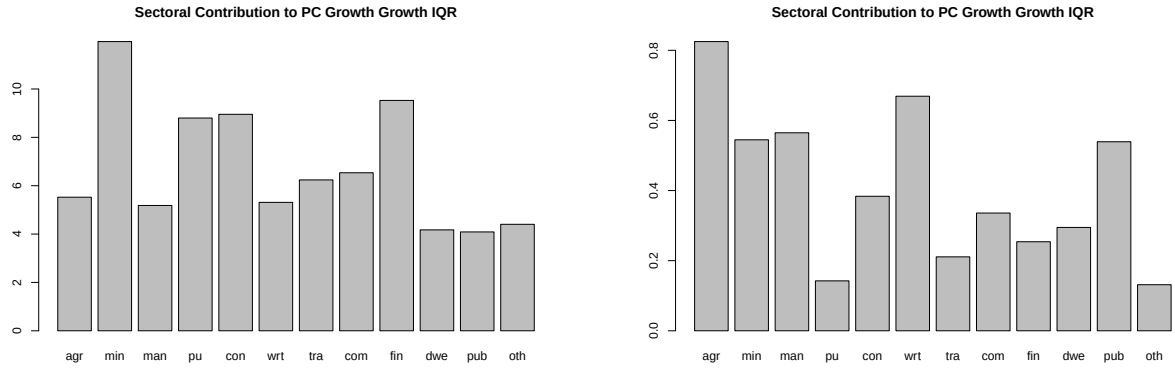


Table A4: Country Classification by Largest Sectoral Contribution to Aggregate Growth Volatility

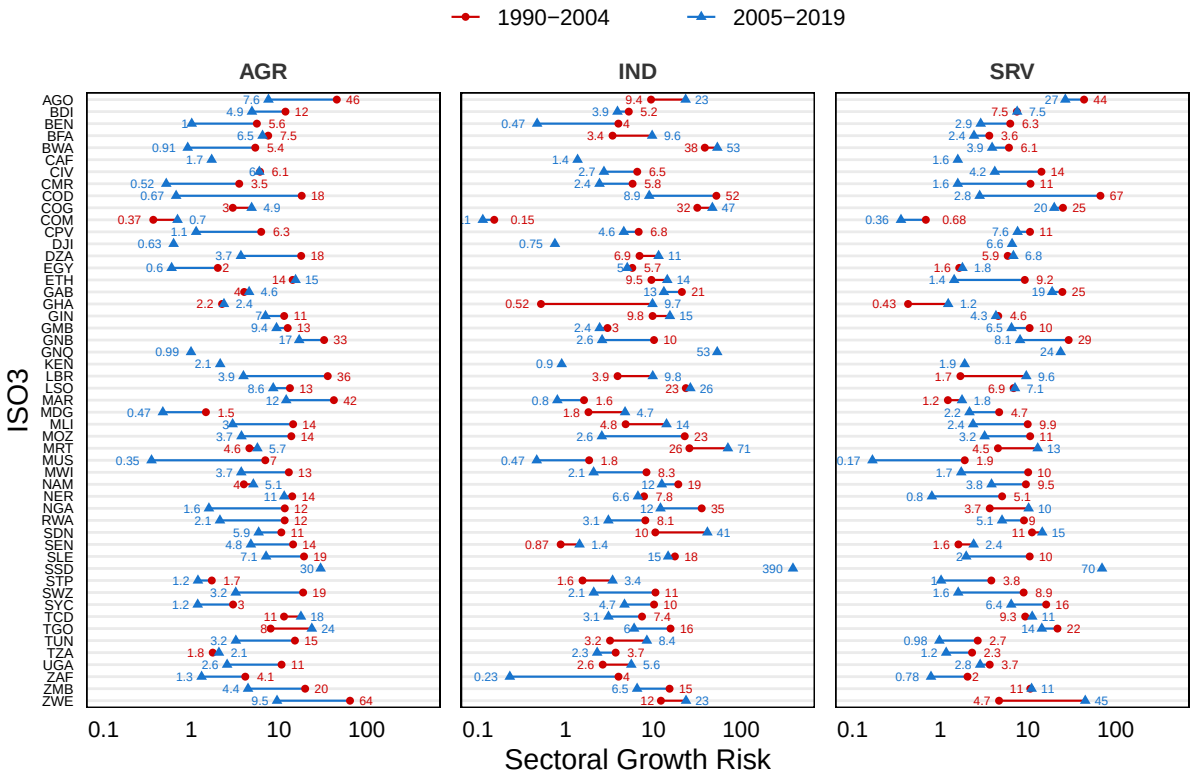
Metric	**AGR** (13)	**IND** (17)	**SRV** (21)
Sectoral Volatility Contribution: MAD$(\Delta y_t/Y_{t-1})$	BDI, BFA, ETH, GNB, LBR, MAR, MLI, NER, SEN, SLE, TCD, UGA, ZWE	AGO, BWA, COD, COG, DZA, EGY, GAB, GIN, GNQ, LSO, MRT, MUS, NGA, SSD, SWZ, TUN, TZA	BEN, CAF, CIV, CMR, COM, CPV, DJI, GHA, GMB, KEN, MDG, MOZ, MWI, NAM, RWA, SDN, STP, SYC, TGO, ZAF, ZMB
Metric	**AGR** (20)	**IND** (21)	**SRV** (10)
Sector Volatile Growth Risk: MAD$(\%\Delta y_t) \times$ MAD$(\Delta y_t/Y_{t-1})$	BDI, BFA, CAF, COM, ETH, GMB, GNB, KEN, MAR, MLI, MUS, MWI, NER, SEN, SWZ, TCD, TUN, UGA, ZAF, ZWE	AGO, BWA, COD, COG, DZA, EGY, GAB, GIN, GNQ, LBR, LSO, MDG, MOZ, MRT, NAM, NGA, SLE, SSD, STP, TZA, ZMB	BEN, CIV, CMR, CPV, DJI, GHA, RWA, SDN, SYC, TGO

Table A5: Aggregate Sectoral Growth Stabilization

Period:	1990-2019			1990-2004			2005-2019		
Sector:	AGR	IND	SRV	AGR	IND	SRV	AGR	IND	SRV
Statistic: Median Across Countries (and Periods)									
$\text{MAD}(\Delta y_t/Y_{t-1})$	1.08	1.18	1.56	1.63	1.21	1.74	0.73	1.06	1.32
$\text{MAD}(\%\Delta y_t)$	5.68	5.47	3.16	6.56	5.74	3.95	5.05	4.81	2.60
$\text{MAD}(\Delta y_t/Y_{t-1}) \times \text{MAD}(\%\Delta y_t)$	5.63	6.71	5.06	11.43	7.59	7.16	3.72	5.79	3.52
Number of Countries Above the 1990-2019 Cross-Country-Period Median									
$\text{MAD}(\Delta y_t/Y_{t-1})$	29	25	25	31	24	27	17	24	21
$\text{MAD}(\%\Delta y_t)$	23	24	31	26	26	29	22	22	19
$\text{MAD}(\Delta y_t/Y_{t-1}) \times \text{MAD}(\%\Delta y_t)$	30	24	31	31	26	28	17	22	20

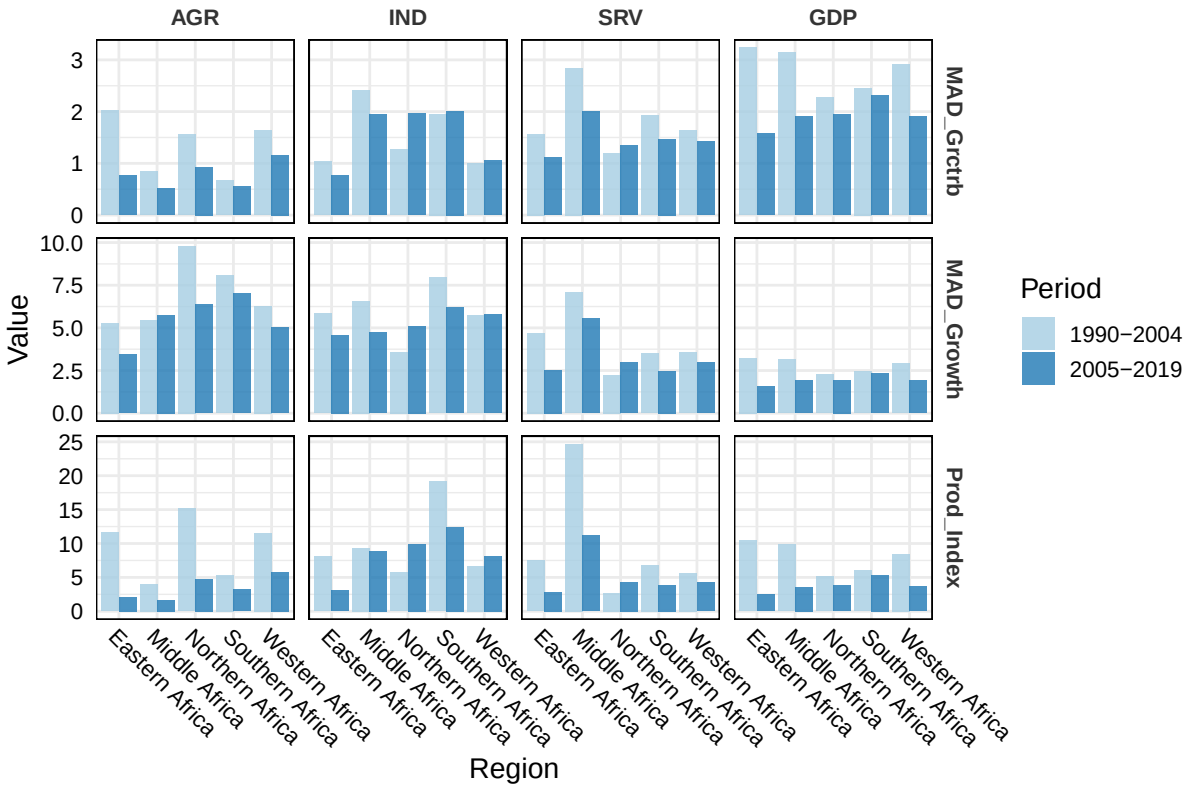
Note: The 1990-2019 statistics are medians across country-level MADs for both the 1990-2004 and 2005-2019 periods. This more accurately reflects the median volatility between these two periods, since country-level MADs calculated over the entire 1990-2019 period are much closer to the 2005-2019 MADs.

Figure A18: Sectoral Growth Risk by Country



Data Source: World Development Indicators, Accessed November 2021

Figure A19: Sectoral Growth Risk by Region



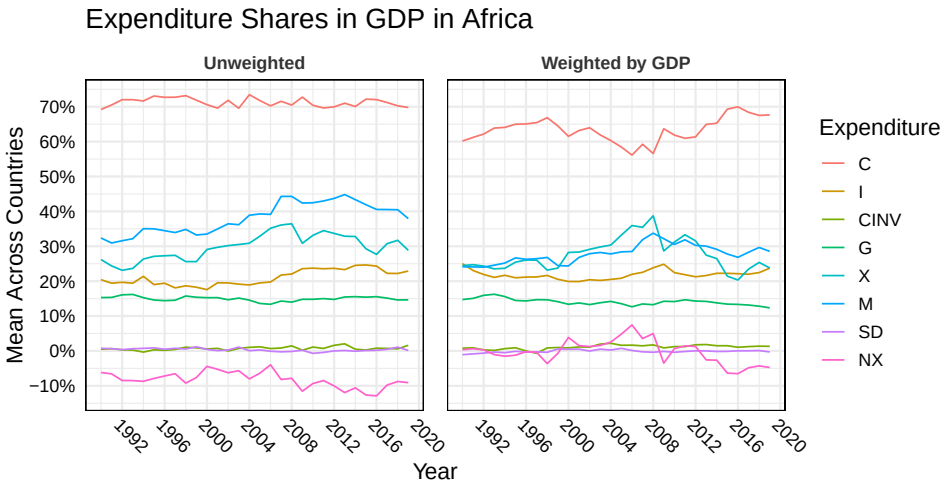
Data Source: World Development Indicators, Accessed November 2021

Table A6: Sectoral Growth Stabilization By Region

			(1) MAD($\Delta y_t/Y_{t-1}$)			(2) MAD($\%\Delta y_t$)			SGR: (1) × (2)		
Region	Period	N	AGR	IND	SRV	AGR	IND	SRV	AGR	IND	SRV
Eastern	1990-2004	13	1.65	1.04	1.61	5.45	5.46	4.23	10.17	6.27	6.48
Eastern	2005-2019	14	0.77	0.78	1.12	3.23	4.62	2.23	2.35	3.47	2.50
Middle	1990-2004	7	0.95	2.41	1.89	6.67	5.80	4.52	8.19	15.80	8.56
Middle	2005-2019	9	0.51	1.94	2.01	5.75	4.72	5.56	1.71	8.94	11.17
Northern	1990-2004	5	1.32	0.79	0.85	8.21	2.55	1.64	10.62	1.92	1.40
Northern	2005-2019	5	0.57	1.57	1.00	6.27	4.87	1.93	3.68	8.40	1.79
Southern	1990-2004	5	0.66	1.65	1.20	7.39	5.27	2.70	4.10	8.74	3.25
Southern	2005-2019	5	0.56	2.01	1.47	7.00	6.18	2.48	3.21	12.43	3.84
Western	1990-2004	15	1.55	0.97	1.54	6.60	5.16	3.22	8.11	7.54	5.86
Western	2005-2019	15	1.14	1.10	1.38	5.04	5.48	2.82	5.96	6.64	4.18

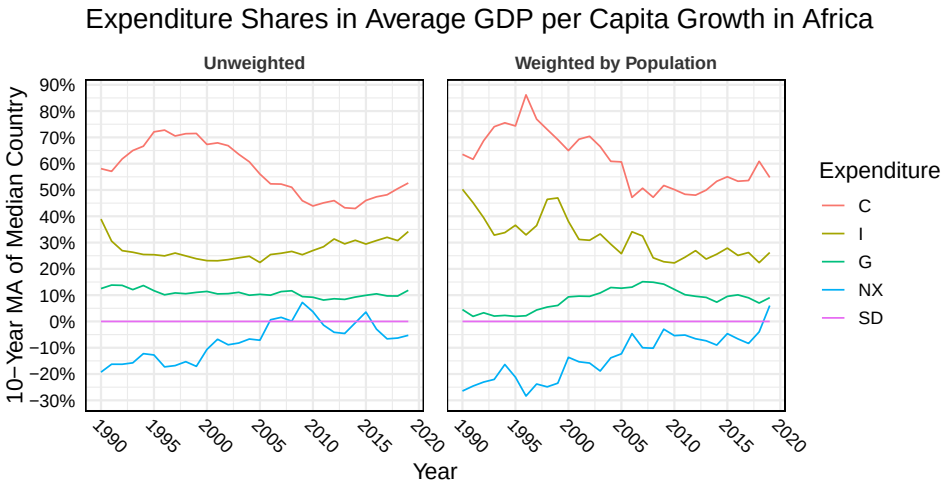
Note: Statistics were aggregated across countries using the median.

Figure A20: GDP Shares: Expenditure Side



Data Source: World Development Indicators, Accessed November 2021

Figure A21: Contributions to GDP Growth: Expenditure Side



Data Source: World Development Indicators, Accessed November 2021

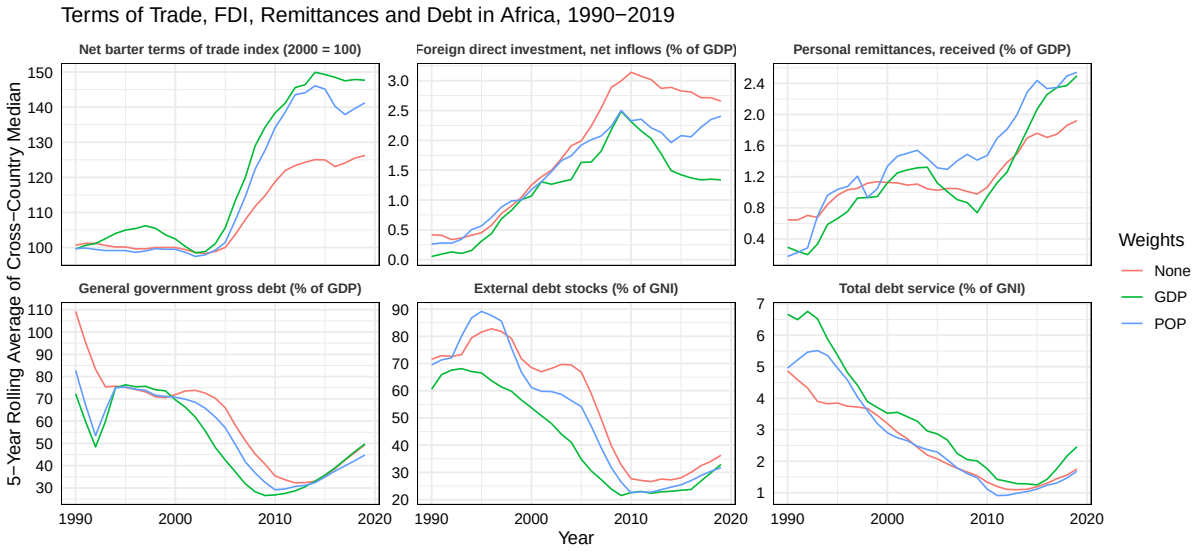
Table A7: Expenditure Volatility and Contribution to Aggregate Volatility, 1990-2019

Data	*Sector*:	C	I	G	X	M	C	I	G	X	M
GDP Share ($\bar{\theta}_k$)		0.691	0.229	0.154	0.303	-0.382	0.688	0.220	0.149	0.299	-0.375
	Cov.:			**Classical**					**Robust**		
Expenditure Growth ($\Delta VA/VA_{t-1}$)	C	42.58					40.59				
	I	4.39	256.62				7.36	220.62			
	G	1.19	8.13	200.03			2.00	36.31	140.81		
	X	-5.20	13.18	-8.90	261.50		-6.18	20.74	-10.70	227.26	
	M	23.18	83.00	6.30	86.84	209.22	24.73	105.44	18.04	63.31	213.27
Expenditure Contribution ($\Delta VA/GDP_{t-1}$)	C	20.92					19.72				
	I	0.06	14.77				0.32	14.99			
	G	0.14	0.40	3.46			-0.09	0.40	2.66		
	X	-0.89	0.79	-0.27	14.16		-0.71	0.97	-0.09	16.64	
	M	-4.33	-7.97	-0.53	-7.13	20.94	-5.31	-7.68	-1.24	-7.00	17.99

Notes: Statistics are aggregated across countries using the median, whereas GDP shares are aggregated across countries using the mean. Average shares for each country are computed using all but the first observation, in line with Eq. 3. The shares reported above "Robust" are computed by taking the median share for each country and aggregating across countries using the mean.

Section 4: External, Financial and Policy Factors

Figure A22: External Environment: Selected Indicators



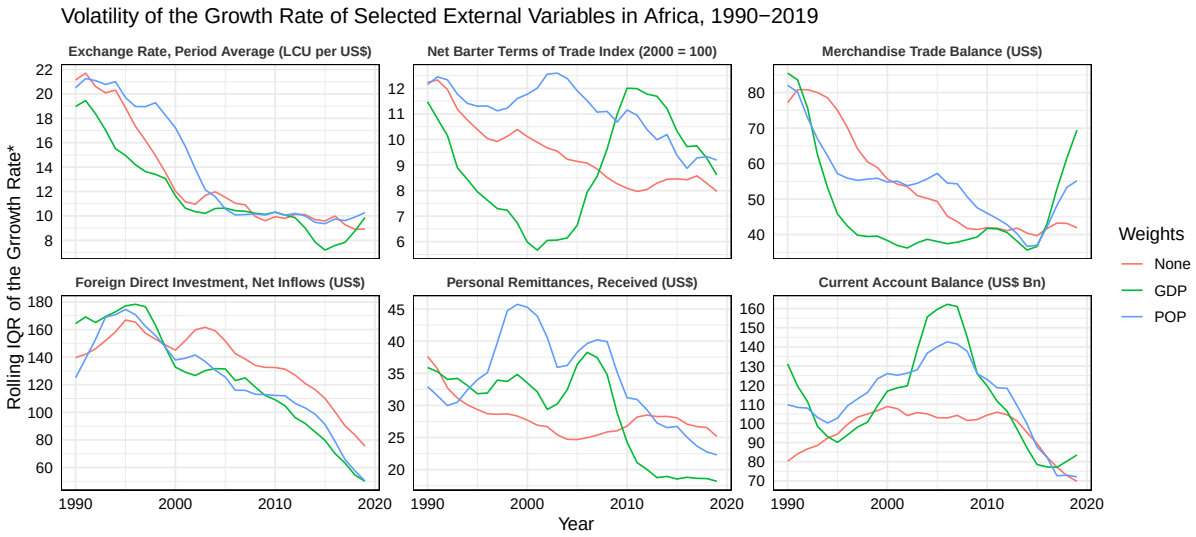
Data Source: IMF and World Bank. Accessed through the africamonitor API.

Table A8: Correlations with External Environment Indicators

Mean:	ToT	FDI	REM	GGDT	EDT	EDS
Median PC Growth	.065*	.177*	.053	-.271*	-.208*	-.045
MAD PC Growth	-.116*	-.052	-.074*	.091*	.104*	.039
Median Inflation	-.057*	-.039	-.083*	.117*	.187*	.084*
MAD Inflation	-.077*	-.031	-.017	.098*	.067*	.035

Notes: A 10-year MA with data from 1981 is used to smooth the variables shown in Figure A22 (in % of GDP/GNI terms), and 10-year rolling medians and MADs for per-capita growth and inflation. These rolling series are then standardized within each country, and first-differenced. Pairwise Pearson's correlations are computed on these first differences across all countries. A star denotes significance at the 5% level.

Figure A23: External Environment Volatility: Selected Indicators



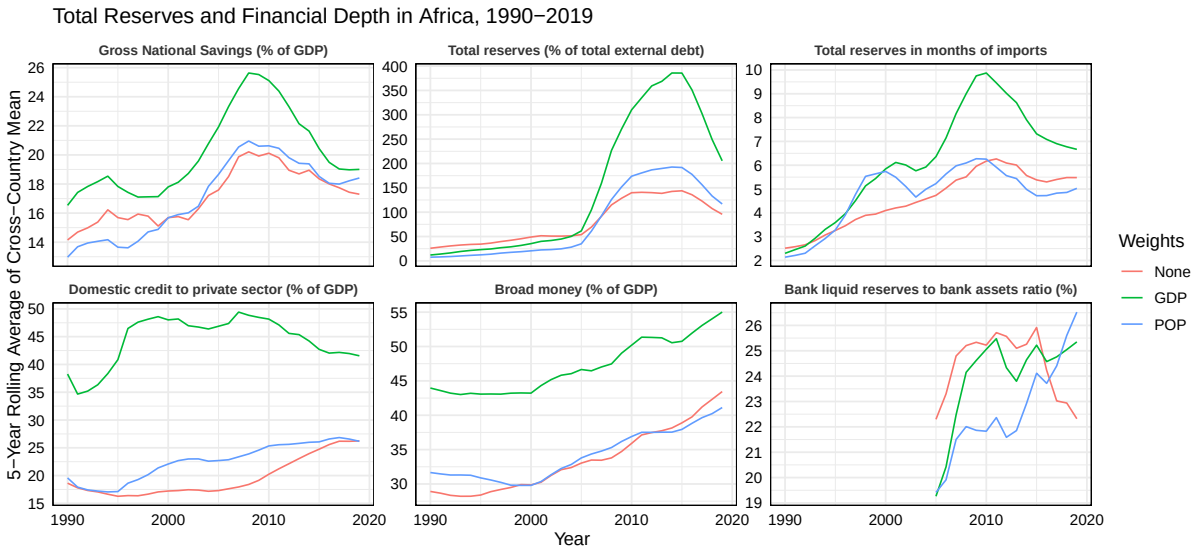
Data Source: IMF and World Bank. Accessed through the africamonitor API.
**Note: Plots show a 5−year MA of the cross−country (weighted) median of a 10−year rolling IQR of the growth rate of the series.*

Table A9: Correlations with External Environment Volatility Indicators

MAD:	E_PA	ToT	TB	FDI	REM	CAB
Median PC Growth	-.173*	-.202*	-.116*	-.034	-.115*	.000
MAD PC Growth	.043	.263*	.093*	.206*	.265*	.153*
Median Inflation	.911*	.299*	.058	.134*	.243*	.048
MAD Inflation	.915*	.295*	.032	.132*	.321*	.060*

Notes: 10-year rolling medians and MADs of the growth rates of the data from 1981 are computed for each country and related through pairwise Pearson's correlations across all countries. A star denotes significance at the 5% level.

Figure A24: Reserves and Financial Depth: Selected Indicators



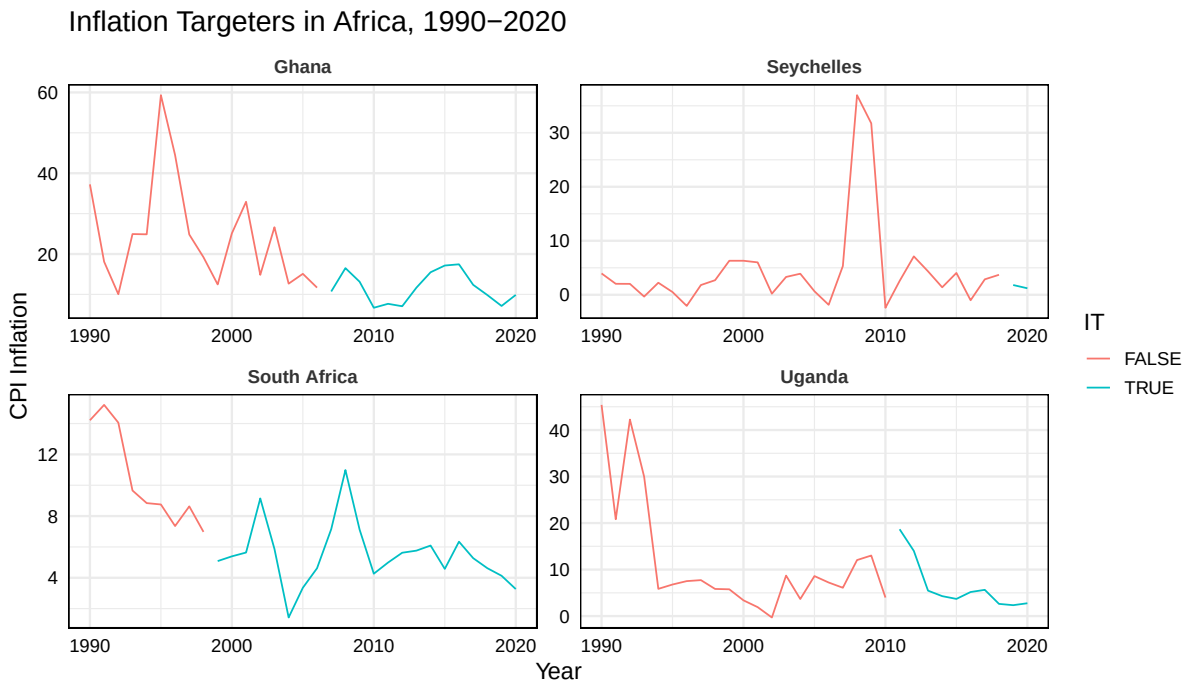
Data Source: IMF and World Bank. Accessed through the africamonitor API.

Table A10: Correlations with Financial Indicators

Mean:	GNS	TR_EDT	TR_MIM	PSC	BM	BLR_A
Median PC Growth	.073*	.249*	.093*	.086*	.072*	-.017
MAD PC Growth	-.024	-.077*	.060	-.106*	-.078*	.035
Median Inflation	-.056*	-.160*	-.050	-.098*	-.090*	-.011
MAD Inflation	-.004	-.035	.006	-.074*	-.078*	-.126*

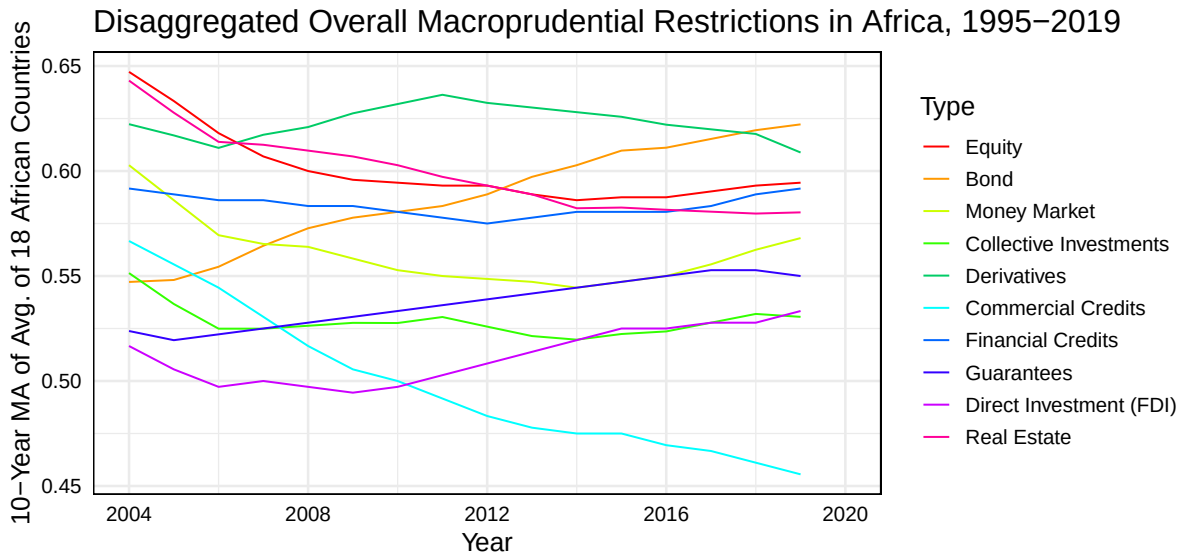
Notes: A 10-year MA with data from 1981 is used to smooth the variables shown in Figure A24, and 10-year rolling medians and MADs for per-capita growth and inflation. These rolling series are then standardized within each country, and first-differenced. Pairwise Pearson's correlations are computed on these first differences across all countries. A star denotes significance at the 5% level.

Figure A25: Inflation Targeting in Africa



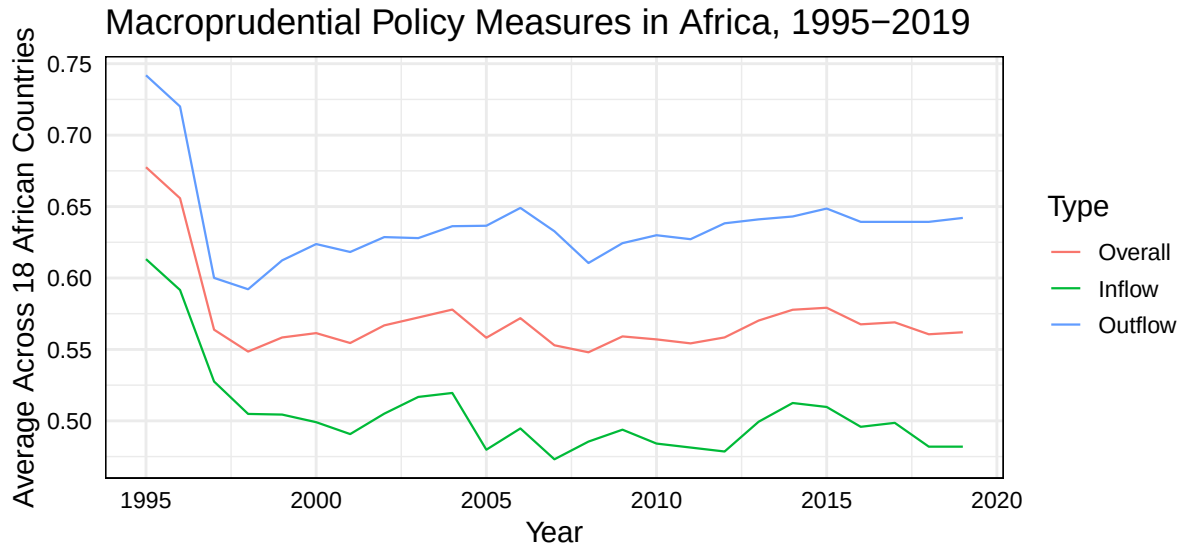
Data Source: IMF World Economic Outlook, October 2021

Figure A26: Disaggregated Macroprudential Measures in Africa



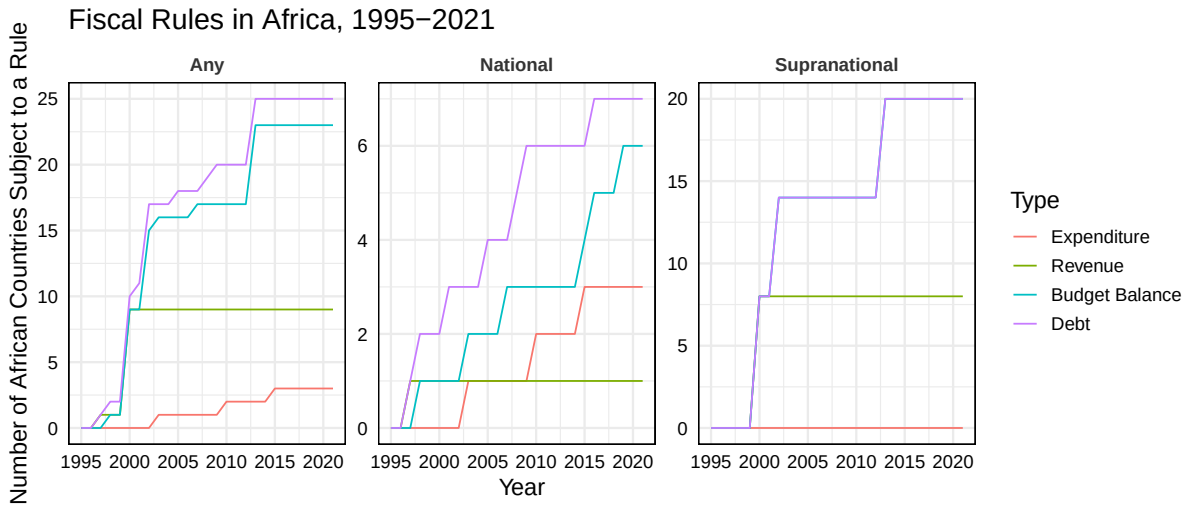
Data Source: Fernandez, Klein, Rebucci, Schindler and Uribe (2016, 2021)

Figure A27: Macroprudential Measures in Africa



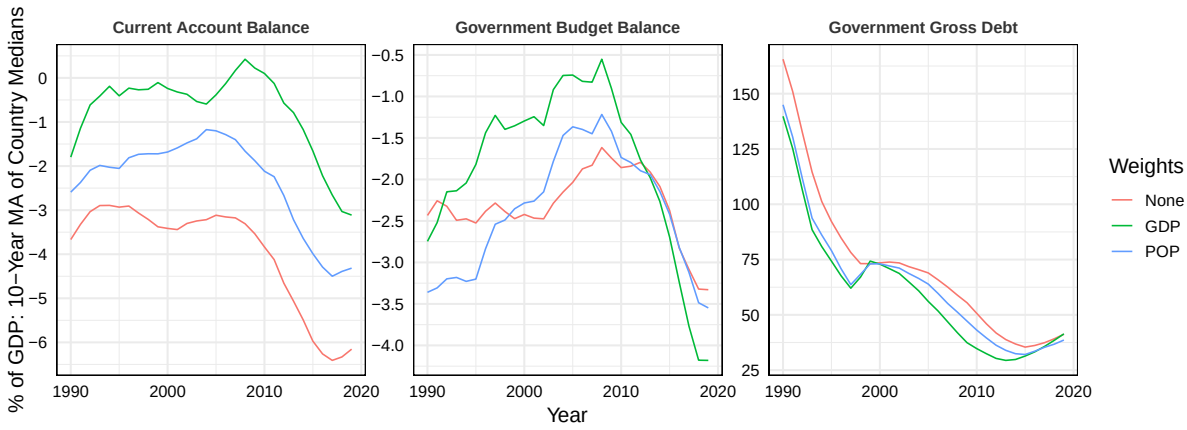
Data Source: Fernandez, Klein, Rebucci, Schindler and Uribe (2016, 2021)

Figure A28: The Adoption of Fiscal Rules in Africa



Data Source: IMF Fiscal Rules Dataset, 2022

Figure A29: Key Macroeconomic and Fiscal Aggregates, 1990-2019



Data Source: IMF World Economic Outlook, October 2021

Table A11: Fiscal Rules: Panel-Regression in 30-Year Panel with Data from 1990-2015

Dependent Variables:	Current Account Balance			Government Budget Balance			Government Gross Debt		
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Any Rule	0.3748	0.1935	1.155	7.645*	8.740*	3.671	-32.86***	-37.18***	-38.99***
	(1.011)	(1.078)	(1.558)	(4.415)	(5.080)	(3.112)	(9.081)	(7.913)	(9.958)
R^2	0.0003	0.260	0.306	0.013	0.143	0.201	0.057	0.434	0.506
Within R^2		< 0.001	0.001		0.016	0.001		0.089	0.046
N. Rules	0.0977	0.0135	0.1347	2.478	2.800	-0.5224	-10.02***	-9.074***	-2.196
	(0.2358)	(0.3457)	(0.3715)	(1.529)	(1.749)	(0.9959)	(2.554)	(2.256)	(1.959)
R^2	<0.001	0.260	0.306	0.010	0.138	0.200	0.039	0.396	0.483
Within R^2		< 0.001	<0.001		0.010	<0.001		0.029	<0.001
ER	4.603***	-6.162***	-5.470**	-0.5070	-13.63**	-11.48*	-26.55***	43.71***	51.35***
	(1.078)	(2.061)	(2.118)	(1.492)	(6.335)	(6.287)	(5.545)	(7.603)	(6.510)
RR	-0.2078	-3.274	-4.546*	-1.307	-17.77*	-25.20**	-1.093	28.14***	8.131
	(1.662)	(2.140)	(2.283)	(0.9910)	(9.362)	(11.35)	(3.214)	(9.968)	(4.862)
BBR	3.246**	3.576***	4.238***	2.788**	7.615	7.374	-7.840	45.23***	51.17***
	(1.577)	(1.142)	(1.270)	(1.291)	(5.273)	(4.772)	(4.624)	(9.988)	(9.414)
DR	-3.138	-0.9916	0.1215	5.647	10.22*	7.303*	-18.55*	-83.44***	-71.83***
	(2.140)	(1.437)	(1.592)	(3.375)	(5.305)	(3.979)	(10.28)	(12.17)	(11.66)
R^2	0.014	0.274	0.322	0.013	0.160	0.225	0.049	0.469	0.542
Within R^2		0.018	0.024		0.035	0.032		0.145	0.115
Fixed-effects									
Country	–	26	30	–	26	30	–	26	30
Year	–	–	26	–	–	26	–	–	26
Observations	749	749	749	673	673	673	586	586	586

Driscoll and Kraay (1998) (L=2) standard-errors in parentheses *Signif. Codes:* ***: 0.01, **: 0.05, *: 0.1

Section 5: Structural Factors

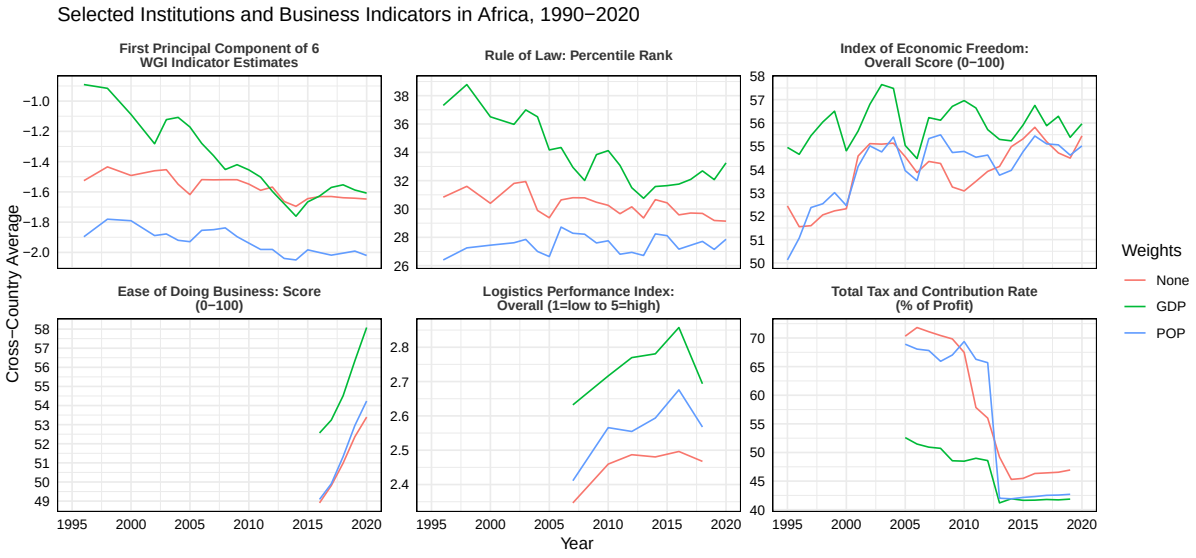
Table A12: Summary Statsitics of Predictors in Cross-Sectional and Panel Analysis

Panel	*Topic* / Variables	N	Ndist	Mean	Median	SD	Min	Max
	Institutions							
	Overall Governance	49	49	49.67	48.57	12	26.35	78.06
X	Worldwide Governance Indicators: PC1	49	49	-1.47	-1.49	1.39	-3.97	1.88
	Human Rights and Rule of Law	49	49	7	7.17	1.53	3.76	9.79
X	Level of Democracy (Freedom House)	49	37	5.27	5	2.64	0.75	10
	50-Year Average Freedom House Ratings	48	29	2.44	2.5	0.5	1	3
X	Regime Durability	47	45	12.51	10.28	9.77	2	39
	Colonial Origin: British	49	2	0.39	0	0.49	0	1
	Colonial Origin: French	49	2	0.39	0	0.49	0	1
	Corruption Perceptions Index	48	44	33.77	32.69	11.35	17	62.25
	Business Environment							
	Ease of Doing Business Score (0-100)	49	47	50.71	50.25	10.99	21.15	77.70
	Logistics Performance Index (1-5)	46	40	2.48	2.47	0.24	2.03	3.50
X	Index of Economic Freedom (0-100)	49	46	53.76	54.80	7.30	34.60	73
X	The Property Right Protection Index	49	49	49.79	50.00	2.12	46.49	54.38
	Production Shares							
X	Agriculture, Forestry & Fishing VA (% of GDP)	49	49	20.89	22.11	13.18	1.33	51.19
X	Industry & Construction VA (% of GDP)	49	49	26.72	22.84	14.73	11.52	77.54
	Climate & Agriculture							
X	Permanent Cropland (% of Land Area)	49	49	4.01	0.74	7.66	0.002	40.62
X	Ln(Cereal Yield, Kg/Ha)	47	47	7.03	7.08	0.61	5.45	8.88
X	Annual Average Rainfall	49	49	82.27	82.98	52.86	2.78	206.82
X	Annual Average Temperature	49	49	24.31	24.48	3.34	12.67	28.87
	% 1995 Pop. in Tropics (Af+Am+Aw)	44	28	46.39	43.04	42.42	0	100
X	% of Cropland Equipped for Irrigation	47	46	7.75	2.11	15.79	0.05	99.81
	Irrigation Suitability 1 (%)	44	44	4.12	3.64	2.81	0.16	13.41
	Soil Suitability 1 (%)	44	44	9.37	7.43	7.79	0.15	32.01
	Trade Intensity and Composition							
X	Merchandise Trade (% of GDP)	49	49	52.39	46.59	25.36	19.22	128.68
X	Agricultural Raw Materials Exports (% of GDP)	47	47	0.96	0.34	1.43	0	7.01
X	Manufactures Exports (% of GDP)	47	47	5.78	1.37	9.08	0.001	35.54
X	Ores and Metals Exports (% of GDP)	47	47	2.49	0.21	4.92	0.0003	22.52
X	Merchandise Exports to HICs (% of GDP)	49	49	13.59	9.90	12.18	0.61	53.02
X	Merch. EX to LMICs Outside Region (% of GDP)	49	49	3.02	1.94	3.87	0.05	17.34
X	Merchandise Imports from HICs (% of GDP)	49	49	15.07	12.76	9.23	3.69	53.41
	Trade Diversification							
X	Herfindahl Index of Bilateral Trade (X+M)	48	48	0.13	0.09	0.10	0.04	0.47
X	Theil Index of Bilateral Trade (X+M)	48	48	2.03	1.87	0.45	1.39	3.29
X	Herfindahl Index of Exports by Product	47	47	0.30	0.27	0.24	0.03	0.92
X	Theil Index of Exports by Product	47	47	3.41	3.32	0.94	1.43	5.46
	Exchange Rate and Terms of Trade							
X	Exchange Rate Growth (%)	49	35	5.32	2.90	7.37	-0.01	44.28
X	MAD Nominal Exchange Rate Depreciation (%)	49	37	10.36	7.94	9.17	0.91	63.23
X	Net Barter Terms of Trade Index (2000 = 100)	49	49	113.10	110.16	20.36	65.92	162.62
X	Terms of Trade Growth (%)	49	46	0.44	0	2.12	-4.37	9.00
X	MAD Terms of Trade Growth (%)	49	49	9.14	7.45	5.70	0.84	24.36
	Financial & Aid Flows							
X	Net FDI Inflows (% of GDP)	49	49	2.52	2.05	2.15	0.04	9.69
X	MAD Diff(FDI in % of GDP)	49	49	1.98	1.29	2.26	0.07	12.88
X	Personal Remittances, Received (% of GDP)	49	45	2.98	1.14	6.04	0	39.72
X	MAD Diff(Remittances in % of GDP)	49	45	0.46	0.21	0.75	0	4.77
X	Net ODA Received (% of GNI)	49	49	7.79	6.73	6.47	0.20	23.07

Panel	*Topic* / Variables	N	Ndist	Mean	Median	SD	Min	Max
	Financial Sector							
X	Broad Money (% of GDP)	49	49	33.79	23.17	25.87	10.11	132.60
X	Broad Money Growth (%)	49	49	8.05	8.05	3.46	-0.03	17.16
X	MAD Broad Money Growth (%)	49	49	14.36	13.26	5.47	2.90	33.26
X	Domestic Credit to Private Sector (% of GDP)	49	49	20.87	13.13	22.95	2.37	118.17
X	Bank Liquid Reserves to Bank Assets Ratio (%)	46	46	21.70	18.83	14.46	3.50	59.29
	Bank/MM Account (% of Population Ages 15+)	42	42	30.47	28.44	19.75	6.71	82.21
	Debt & Reserves							
X	General Government Gross Debt (% of GDP)	48	48	56.24	52.95	31.71	12.92	198.71
X	External Debt Stocks (% of GNI)	45	45	62.83	55.79	35.70	12.71	196.62
X	Total Debt Service (% of GNI)	45	45	2.85	2.08	2.34	0.62	12.54
X	Total Reserves in Months of Imports	41	41	4.62	2.99	6.03	0.07	28.19
	Population							
X	Ln(Population)	49	49	15.76	16.11	1.62	11.33	18.74
X	Population Growth (Annual %)	49	49	2.39	2.57	0.78	0.61	4.10
X	Urban Population (% of Total Population)	49	49	39.38	38.02	16.88	9.26	82.12
X	Ln(Population Density, People/Km2)	49	49	3.68	3.88	1.33	0.85	6.40
X	Age Dependency Ratio (% of Work. Age Pop.)	49	49	83.26	87.86	15.71	45.86	106.47
X	International Migrant Stock (% of Population)	49	49	3.13	2.26	3.46	0.15	15.55
	Health							
X	Life Expectancy at Birth, Total (Years)	49	49	57.22	55.66	7.81	43.98	74.13
X	Infant Mortality Rate (per 1000 Live Births)	49	49	63.75	67.15	26.01	12.20	125.65
X	% of People using Basic Sanitation Services	49	49	38.27	31.45	26.67	5.81	98.17
	% Pop. at Risk of Malaria, 2005	44	14	75.21	100	40.01	0	100
	Malaria Ecology (Sachs, 2003)	47	47	10.16	7.51	8.53	0	31.55
	Education							
X	Human Capital Index	49	49	0.53	0.55	0.17	0.16	0.82
X	Mean Years of Schooling	49	36	4.37	4.30	1.93	1.30	8.90
X	Expected Years of Schooling	49	39	9.12	9	2.60	3.70	15.40
X	Adult Literacy (% of People Ages 15+)	49	49	62.83	67.09	19.91	23.00	93.00
	% of Pop. Speaking Major European Language	48	11	3.37	0	12.88	0	70.00
	Natural Disasters & Conflict							
X	Natural Disasters: Ln(N. Homeless)	49	45	9.39	10.91	3.81	0	13.83
X	Natural Disasters: Ln(N. Deaths)	49	49	6.84	7.27	2.12	1.39	10.13
X	Natural Disasters: Ln(Damage in USD)	49	39	8.69	10.34	5.27	0	15.69
X	Ln(ACLED Fatalities, 1997-2019)	44	44	7.49	7.60	2.50	1.39	11.88
	Societal Violence Scale Index (1-5)	48	13	3.44	3.58	0.92	1.50	5
X	State Fragility Index	47	43	14.36	15.04	4.88	1.33	23.33
	Geography & Accessibility							
	Geogr. Predicted Trade (FR 1999)	48	48	-3.07	-3.08	0.50	-3.98	-2.16
	% Area 100km from Coast/Sea-Nav. River	44	32	20.61	12.09	26.19	0	100
	Sub-Saharan Africa Dummy	49	2	0.90	1	0.31	0	1
	Landlocked Dummy	48	2	0.27	0	0.45	0	1
	Internal Distance Based on Area	48	48	232.83	205.27	159.59	8.02	595.40
	Latitude in Degrees	48	47	2.52	4.85	17.41	-33.93	36.83
	Longitude in Degrees	48	47	15.08	14.12	20.75	-23.50	57.50
	Natural Resources							
X	Total Natural Resources Rents (% of GDP)	49	49	10.88	7.37	10.58	0.01	42.04
X	Oil Rents (% of GDP)	49	20	4.48	0	10.16	0	40.52

Panel	*Topic* / Variables	N	Ndist	Mean	Median	SD	Min	Max
	Poverty & Inequality							
X	% Poor at $1.90 a Day (2011 PPP)	46	44	39.11	41	23.95	0.40	85.75
X	Poverty Gap at $1.90 a Day (2011 PPP) (%)	46	45	15.96	15.03	12.46	0.10	51.70
X	Gini Index	46	44	43.37	41.68	7.87	31.45	63
	Religion & Ethnicity							
	Religion: Muslim, 1980	45	38	32.82	16.20	36.80	0	99.40
	Religion: Protestant, 1980	45	35	11.52	4.90	13.25	0	50
	Religion Fractionalization, 2000	49	49	0.47	0.58	0.27	0.003	0.86
	Ethnic Fractionalization, 2000	48	47	0.62	0.71	0.25	0	0.93
	Others							
X	Index of Globalization	49	49	44.31	43.29	8.33	28.37	62.70
X	Human Development Index	49	49	0.49	0.48	0.12	0.30	0.76
	Ln(GDP per Capita 1960)	42	41	6.57	6.51	0.54	5.52	7.94
X	Ln(GDP per Person Employed)	47	47	9.16	8.96	1.04	7.51	11.16
X	Access to Electricity (% of Population)	49	49	41.00	34.75	29.66	5.05	99.40
X	Gross National Savings (% of GDP)	48	48	17.38	15.81	9.14	2.31	37.98

Figure A30: Institutions and Business Environment: Selected Indicators



Source: IMF and World Bank. Accessed through the africamonitor API.

Figure A31: RF Predicting the MAD-Difference of PCGDP Growth of 49 African Economies

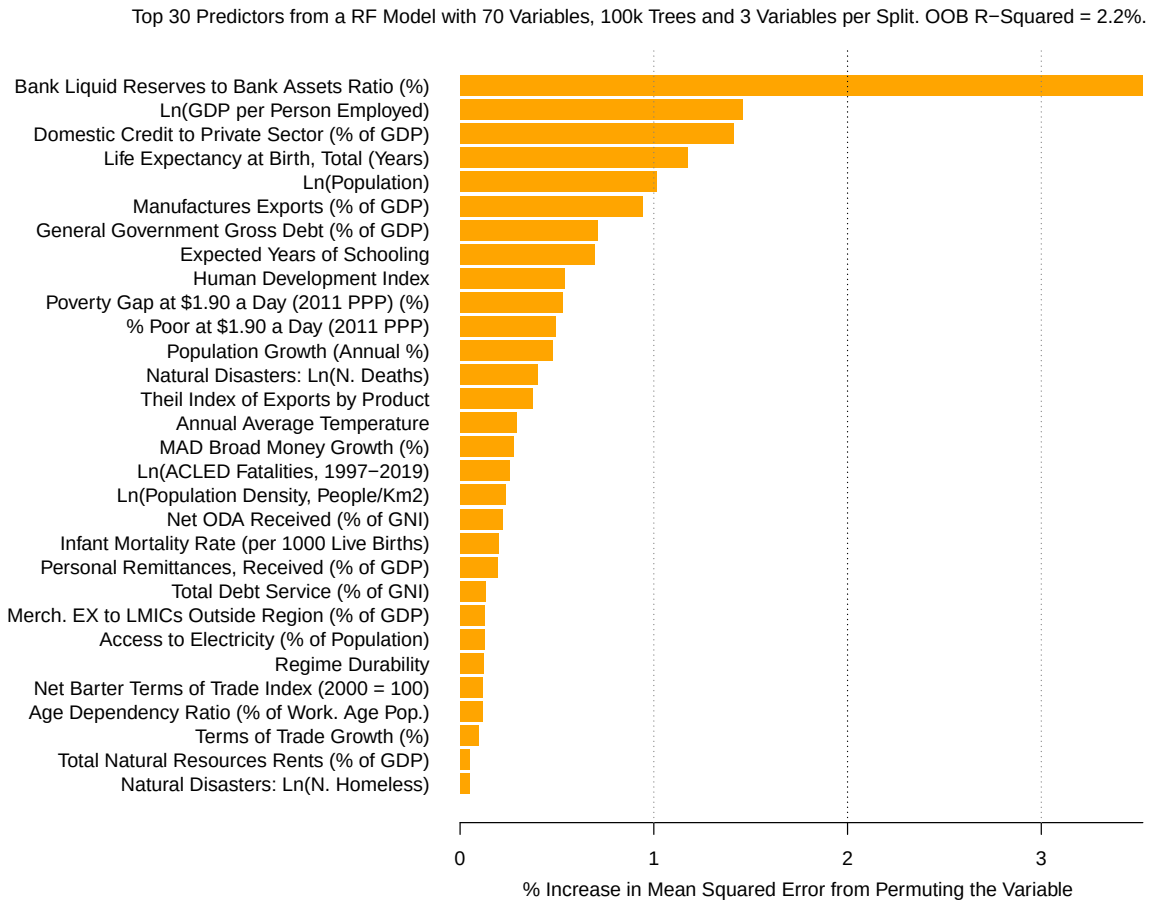


Table A13: RF Ranking of Indicator Topics: Predicting the MAD-Difference of PCGDP Growth

Method:	Permutation		Exclusion		Residual Fit		Combined
Topic	%ΔMSE	Rank	%ΔMSE	Rank	%ΔMSE	Rank	Avg. Rank
Others	63.47	3	2.29	2	16.29	1	2.00
Financial Sector	68.48	2	7.05	1	7.84	7	3.33
Population	44.62	4	0.37	6	8.83	4	4.67
Health	34.72	6	0.37	5	1.21	11	7.33
Institutions	23.60	14	0.47	3	8.65	6	7.67
Education	24.29	13	0.30	7	13.37	3	7.67
Trade Intensity and Composition	74.42	1	-1.25	15	5.06	8	8.00
Climate & Agriculture	30.06	8	-0.28	12	8.75	5	8.33
Debt & Reserves	28.69	9	-1.38	16	13.44	2	9.00
Trade Diversification	33.82	7	-0.89	13	1.53	10	10.00
Natural Disasters & Conflict	39.17	5	-0.09	10	-3.17	17	10.67
Exchange Rate and ToT	27.29	10	-0.05	9	-0.87	15	11.33
Financial & Aid Flows	24.47	12	-0.15	11	0.78	12	11.67
Poverty & Inequality	16.19	16	0.42	4	-2.98	16	12.00
Natural Resources	25.97	11	-1.52	17	3.30	9	12.33
Business Environment	11.88	17	0.26	8	0.07	13	12.67
Production Shares	16.27	15	-0.92	14	-0.01	14	14.33

Figure A32: RF Predicting the MAD-Difference of CPI Inflation of 49 African Economies

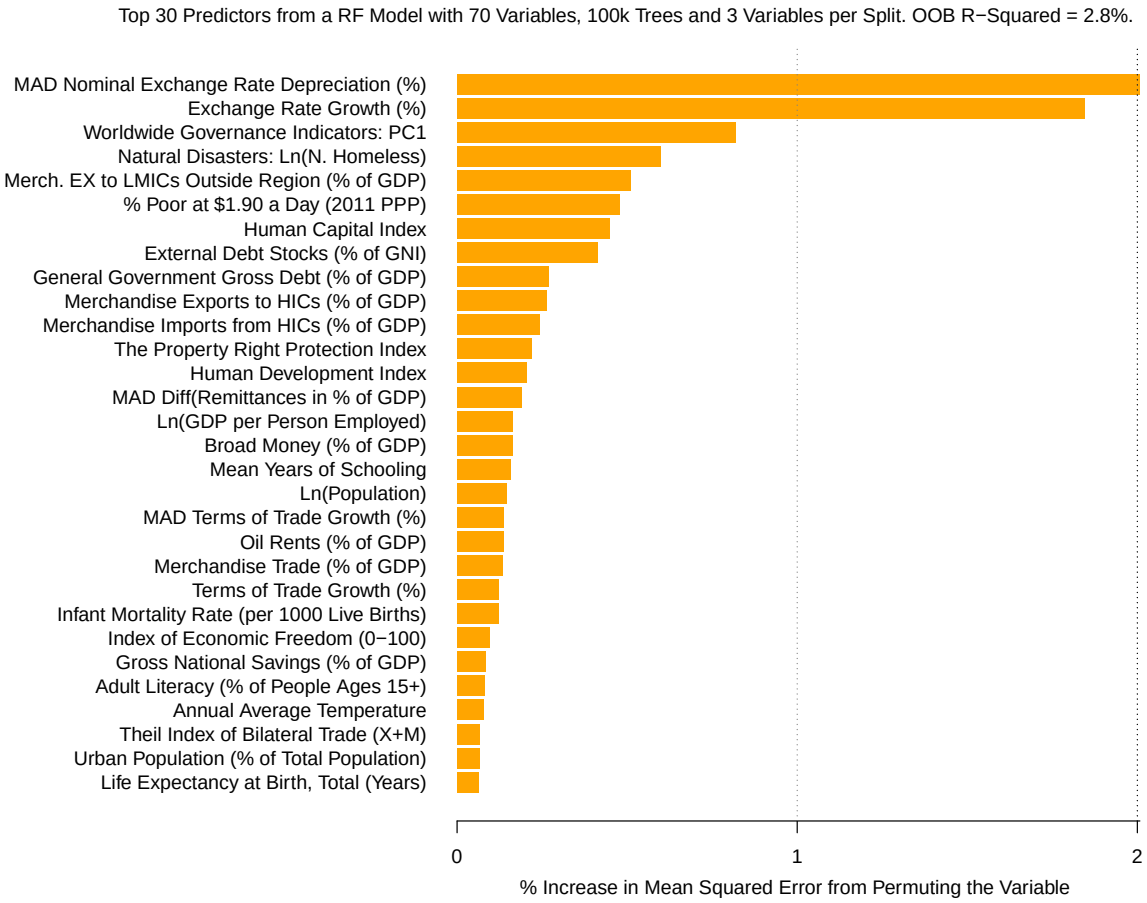


Table A14: RF Ranking of Indicator Topics: Predicting the MAD-Difference of CPI Inflation

Method:	Permutation		Exclusion		Residual Fit		Combined
Topic	%ΔMSE	Rank	%ΔMSE	Rank	%ΔMSE	Rank	Avg. Rank
Exchange Rate and ToT	62.34	2	7.87	1	36.45	1	1.33
Population	68.14	1	-0.01	7	2.10	3	3.67
Debt & Reserves	61.76	3	-1.12	15	2.89	2	6.67
Institutions	22.22	13	0.55	2	1.35	6	7.00
Natural Disasters & Conflict	37.33	9	0.26	4	0.79	9	7.33
Trade Intensity and Composition	39.68	7	0.29	3	-1.69	13	7.67
Production Shares	38.81	8	0.05	6	0.41	10	8.00
Education	45.36	4	-0.03	8	-1.80	15	9.00
Natural Resources	4.70	17	0.18	5	1.43	5	9.00
Climate & Agriculture	32.01	10	-0.84	14	1.25	7	10.33
Financial Sector	42.28	5	-0.05	9	-5.75	17	10.33
Health	25.41	11	-0.37	10	-0.32	11	10.67
Poverty & Inequality	19.66	14	-1.28	16	1.61	4	11.33
Trade Diversification	23.90	12	-0.56	12	-1.20	12	12.00
Business Environment	5.95	16	-0.67	13	1.23	8	12.33
Financial & Aid Flows	42.13	6	-1.29	17	-2.60	16	13.00
Others	13.40	15	-0.42	11	-1.72	14	13.33

Cross-Sectional Prediction: With First 2 Principal Components for Each Topic

Table A15: Percent Variance Explained by First 2 Principal Components

		% Variance Explained		
Topic	N	PC1	PC2	Total
Institutions (excl. Colonial Origin)	7	66.86	16.29	83.16
Business Environment	4	76.24	13.38	89.62
Production Shares	2	82.30	17.70	100.00
Climate & Agriculture	8	34.76	21.51	56.27
Trade Intensity and Composition	7	35.04	20.03	55.07
Trade Diversification	4	51.14	27.62	78.75
Exchange Rate and ToT	5	42.81	34.21	77.02
Financial & Aid Flows	5	40.12	34.34	74.46
Financial Sector	6	40.30	24.56	64.86
Debt & Reserves	4	38.84	27.70	66.54
Population	6	39.68	24.03	63.71
Health	5	73.36	12.26	85.63
Education	5	73.77	18.01	91.79
Natural Disasters & Conflict	6	52.65	18.79	71.44
Geography & Accessibility	7	37.78	28.31	66.09
Natural Resources	2	93.18	6.82	100.00
Poverty & Inequality	3	68.30	30.29	98.59
Religion & Ethnicity	4	60.32	24.71	85.04
Others	6	69.91	11.03	80.94
Average	5.05	56.70	21.66	78.37

Table A16: RF Ranking of Indicator Topics: PC12 Predicting MAD PCGDP Growth, 1990-2019

Method:	Permutation		Exclusion		Residual Fit		Combined
Topic	%ΔMSE	Rank	%ΔMSE	Rank	%ΔMSE	Rank	Avg. Rank
Financial Sector	114.50	1	2.48	3	34.07	3	2.33
Production Shares	61.84	4	4.47	1	29.96	5	3.33
Institutions	35.02	6	2.84	2	31.12	4	4.00
Financial & Aid Flows	102.31	2	1.65	4	29.21	6	4.00
Natural Resources	30.86	7	0.88	6	38.82	2	5.00
Trade Intensity and Composition	68.14	3	-1.36	14	48.70	1	6.00
Population	19.52	10	0.88	5	12.82	8	7.67
Trade Diversification	13.92	12	-0.42	8	1.57	14	11.33
Natural Disasters & Conflict	35.68	5	-1.10	13	0.78	16	11.33
Business Environment	23.65	9	-2.32	17	11.53	10	12.00
Exchange Rate and ToT	12.02	13	-1.87	16	19.43	7	12.00
Debt & Reserves	17.17	11	-2.60	18	12.00	9	12.67
Climate & Agriculture	11.98	14	-1.37	15	9.50	11	13.33
Geography & Accessibility	9.80	15	-0.38	7	-10.29	19	13.67
Poverty & Inequality	3.57	19	-0.72	10	2.19	12	13.67
Education	8.60	16	-0.45	9	-2.46	17	14.00
Religion & Ethnicity	5.53	18	-0.91	11	1.63	13	14.00
Health	6.07	17	-1.02	12	0.94	15	14.67
Others	25.18	8	-3.33	19	-3.09	18	15.00

Table A17: RF Ranking of Indicator Topics: PC12 Predicting MAD CPI Inflation, 1990-2019

Method:	Permutation		Exclusion		Residual Fit		Combined
Topic	%ΔMSE	Rank	%ΔMSE	Rank	%ΔMSE	Rank	Avg. Rank
Exchange Rate and ToT	225.75	1	19.91	1	42.39	1	1.00
Institutions	58.74	4	1.30	2	23.53	3	3.00
Natural Disasters & Conflict	61.13	2	0.61	3	22.97	4	3.00
Business Environment	43.39	6	-0.01	5	11.64	7	6.00
Population	15.61	12	-0.01	4	26.71	2	6.00
Geography & Accessibility	19.32	9	-0.79	9	16.46	6	8.00
Natural Resources	59.37	3	-4.29	18	17.97	5	8.67
Others	20.09	8	-1.99	14	11.49	8	10.00
Financial Sector	17.26	11	-0.73	8	0.26	14	11.00
Trade Diversification	10.41	14	-0.22	6	0.16	15	11.67
Poverty & Inequality	44.91	5	-4.60	19	7.90	12	12.00
Health	11.58	13	-2.06	15	8.44	10	12.67
Climate & Agriculture	5.27	19	-0.30	7	3.23	13	13.00
Education	5.58	18	-0.86	10	8.21	11	13.00
Financial & Aid Flows	17.57	10	-1.54	12	-11.58	18	13.33
Religion & Ethnicity	9.38	15	-3.13	17	8.96	9	13.67
Debt & Reserves	38.12	7	-2.63	16	-19.02	19	14.00
Trade Intensity and Composition	9.08	17	-1.44	11	-0.28	16	14.67
Production Shares	9.08	16	-1.97	13	-1.67	17	15.33

Panel Prediction: With First 2 Principal Components for Each Topic

Table A18: Percent Variance Explained by First 2 Principal Components

		% Variance Explained		
Topic	N	PC1	PC2	Total
Institutions	3	47.87	40.35	88.22
Business Environment	2	61.01	38.99	100.00
Production Shares	2	73.69	26.31	100.00
Climate & Agriculture	5	35.72	21.57	57.29
Trade Intensity and Composition	7	38.79	23.46	62.26
Trade Diversification	4	43.20	22.48	65.69
Exchange Rate and ToT	5	40.17	28.43	68.61
Financial & Aid Flows	5	39.57	33.53	73.10
Financial Sector	5	36.74	27.05	63.79
Debt & Reserves	4	46.07	28.98	75.05
Population	6	44.68	22.30	66.98
Health	3	58.92	32.95	91.87
Education	4	40.36	28.70	69.06
Natural Disasters & Conflict	5	31.21	20.61	51.82
Natural Resources	2	80.75	19.25	100.00
Poverty & Inequality	3	68.51	27.15	95.66
Others	5	29.37	23.56	52.93
Average	4.12	48.04	27.39	75.43

Table A19: RF Ranking of Indicator Topics: PC12 Predicting MAD-Difference of PCGDP Growth

Method:	Permutation		Exclusion		Residual Fit		Combined
Topic	%ΔMSE	Rank	%ΔMSE	Rank	%ΔMSE	Rank	Avg. Rank
Others	83.95	1	1.98	3	11.13	1	1.67
Exchange Rate and ToT	45.31	4	4.34	1	3.39	6	3.67
Financial Sector	35.92	7	2.24	2	4.56	3	4.00
Natural Resources	63.17	3	0.55	7	5.68	2	4.00
Institutions	44.60	5	1.21	5	4.00	4	4.67
Natural Disasters & Conflict	76.57	2	1.47	4	-5.28	17	7.67
Financial & Aid Flows	12.61	15	0.72	6	2.36	7	9.33
Health	25.13	9	-1.76	16	3.97	5	10.00
Debt & Reserves	26.06	8	-0.91	15	1.72	8	10.33
Trade Intensity and Composition	36.89	6	-0.87	14	-2.50	12	10.67
Population	19.11	10	-0.24	11	-1.43	11	10.67
Business Environment	13.99	13	-0.07	9	-3.23	13	11.67
Climate & Agriculture	7.50	17	-0.13	10	0.89	9	12.00
Production Shares	17.46	12	-0.70	13	-3.26	14	13.00
Trade Diversification	17.49	11	-0.67	12	-4.90	16	13.00
Poverty & Inequality	11.56	16	0.09	8	-3.68	15	13.00
Education	13.49	14	-1.91	17	0.43	10	13.67

Table A20: RF Ranking of Indicator Topics: PC12 Predicting MAD-Difference of CPI Inflation

Method:	Permutation		Exclusion		Residual Fit		Combined
Topic	%ΔMSE	Rank	%ΔMSE	Rank	%ΔMSE	Rank	Avg. Rank
Exchange Rate and ToT	106.41	1	8.15	1	25.13	1	1.00
Debt & Reserves	43.52	5	0.15	6	5.97	2	4.33
Production Shares	96.40	2	1.52	2	0.86	12	5.33
Poverty & Inequality	6.23	13	0.25	4	2.58	6	7.67
Climate & Agriculture	38.44	6	-0.15	8	0.97	11	8.33
Natural Resources	8.82	12	-0.20	10	3.66	3	8.33
Health	72.33	3	-0.68	15	1.28	8	8.67
Education	46.45	4	-1.51	17	2.98	5	8.67
Population	36.27	7	1.11	3	-2.30	17	9.00
Natural Disasters & Conflict	11.64	11	0.02	7	1.22	9	9.00
Institutions	13.15	10	-0.64	14	2.33	7	10.33
Financial Sector	24.62	8	-0.48	12	0.42	13	11.00
Business Environment	5.09	15	-1.01	16	3.55	4	11.67
Trade Diversification	13.46	9	-0.64	13	0.13	14	12.00
Financial & Aid Flows	4.99	16	-0.40	11	0.98	10	12.33
Trade Intensity and Composition	5.93	14	-0.19	9	-0.73	15	12.67
Others	2.60	17	0.25	5	-0.91	16	12.67