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Sources of Inflation in Sub-Saharan Africa

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Abstract

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This paper explores the sources of inflation in Sub-Saharan Africa by examining the relationship between inflation, the output gap, and the real money gap. Using heterogeneous panel cointegration estimation techniques, we estimate cointegrating vectors for the production function and the real money demand function to recover the structural output and money gaps for seventeen African countries. The central finding is that both gaps contain significant information regarding the evolution of inflation, albeit with a larger role played by the money gap. There is no significant evidence of asymmetry in the relationship.

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I. INTRODUCTION

An important relationship, relatively undocumented for Sub-Saharan African (SSA) countries, is the Phillips curve, which represents the trade-off between inflation and excess demand in the economy. Evaluating excess demand is notoriously difficult, especially for developing economies where commonly used measures such as NAIRU (non-accelerating inflation rate of unemployment) are unavailable. We close this gap by constructing measures of inflationary pressures due to excess demand: the output gap and the real money gap. Our measures could be important not only for forecasting inflation, but also building macroeconomic models for policy analysis, including financial programming models used by the IMF (see Mikkelsen, 1998).

A number of authors have attempted to identify the sources of inflation in SSA. However, they have generally taken a reduced-form VAR approach (e.g. Fielding, Lee, and Shields (2005), Mikkelsen and Peiris (2005)) and have not estimated the short-term trade-off between inflation and excess demand due to insufficient data. Money demand in SSA has been more thoroughly investigated (e.g. Nachegea (2001) on Uganda, Rother (1999) on the West African monetary union, or Jenkins (1999) on Zimbabwe), but studies have rarely directly related monetary aggregates to inflation dynamics.

In this paper, we analyze the determination of inflation in SSA, particularly the role of the output gap and the real money gap. There are two basic methodologies for recovering unobserved components such as potential output: statistical detrending or estimation of structural relationships (see Cerra and Saxena (2000), Coe and McDermott (1997)). In this paper, we recover the unobserved structural (output and money) gaps for a sample of SSA countries by using a panel cointegration approach and economic theory to isolate the effects of structural and cyclical influences. That way, we can mitigate the problem of small sample bias that has prevented the reliable estimation of those structural gaps in most SSA countries. We then use a panel GMM estimator to test the role of output and money gaps in determining inflation in SSA. To preview our results, we find that our two measured gaps both contain robust and considerable information regarding the evolution of inflation.

The paper is organized as follows: section II takes a short look at the sources of inflation and the Phillips curve in theory; section III describes the procedure followed to estimate the output and real money gaps; section IV describes the data; and section V presents the panel estimations of an augmented-Phillips curve.

II. INFLATION DETERMINATION

In developing countries, there are four frequently cited sources of inflation:¹

- **Demand pressures:** a standard measure of the relative pace of economic activity is the output gap, the difference between output and potential output.
- **Fiscal and monetary policies:** fiscal imbalances in developing countries with scarce resources often lead to monetization of the fiscal deficit. To capture inflationary pressures stemming from “excess” money supply, we consider the real money gap, the difference between real money stock and equilibrium real money stock (the level equal to real money demand).
- **Supply shocks:** changes in the terms of trade, drought, or conflict can lead to persistent changes in the price level.
- **Inertia:** inflation may have a dynamic component arising from the sluggish adjustment of expectations or the existence of staggered wage contracts.

Therefore, as in Gerlach and Svensson, (2003), we will consider an augmented-Phillips curve of the general form:²

$$\pi_{t+1} = \pi_{t+1,t}^e + \alpha_y (y_t - y_t^*) + \alpha_m (m_{t+1} - m_{t+1}^*) + \alpha_z z_{t+1} + \varepsilon_{t+1} \quad (1)$$

where π is the annualized inflation rate, $\pi_{t+1,t}^e$ is expected future inflation at t , y_t is output, y_t^* potential output, $m_{t+1} - m_{t+1}^*$ real money gap, z_{t+1} is an exogenous variable or shift factor such as a supply shock, and ε_t an identically and independently distributed “cost-push” shock.³

We will model expected inflation by lagged inflation and assume $\pi_{t+1,t}^e = \alpha_\pi \pi_{t-1}$. Christiano, Eichenbaum, and Evans (2005) and Woodford (2003) provide a rationale for including lagged inflation in the Philips curve based on alternative assumptions regarding optimal price setting behavior of firms while Rudebusch (2000) estimates that US inflation is predominantly backward looking. As such, given data limitations and absence of surveys on inflationary expectations in SSA, the estimated Philips curves will only include lagged inflation.

¹ See for example Loungani and Swagel (2001)

² The new-Keynesian Phillips curve is a relation between inflation and real marginal cost as opposed to inflation and a measure of the gap between actual output and some measure of potential output (Walsh (2003)). Since there is no data on labor productivity in SSA, we will only focus on a more traditional Phillips curve.

³ Note that African data are available only on an annual basis. A reasonable assumption is then to allow the real money gap to have an “immediate” impact on inflation while letting the output gap have only a lagged impact.

III. MEASURING THE OUTPUT AND REAL MONEY GAPS

The output and real money gaps are the two crucial variables measuring demand pressures that generate inflation. Measuring them is nevertheless notoriously difficult because we need to isolate long-run movements from short-run fluctuations capturing demand variations.

Our general approach in this paper is to identify long-run trends through cointegration relationships. For the output gap, provided that there is cointegration, we are able to estimate a cointegrating vector (α, β) by postulating a simple two-factor Cobb-Douglas production function:

$$\ln(Y_{i,t}) = c + \alpha \ln(K_{i,t}) + \beta \ln(L_{i,t}) + tfp_{i,t} + \varepsilon_{i,t}^y \quad (2)$$

where $tfp_{i,t}$ is total factor productivity. Provided that $\varepsilon_{i,t}^y$ is stationary, we can interpret the short-term deviation around the estimated long-term output as the output gap. For comparison, we will also use statistical detrending and estimate potential output with the Hodrick-Prescott filter.

To define the real money gap, we must estimate a long-run money demand function.⁴ Because of a lack of reliable data and absence of market-determined interest rates in many SSA countries, at least until recently, we assume a simple specification for money demand that disregards the opportunity cost of holding money⁵:

$$\ln \left[\frac{M_{i,t}}{P_{i,t}} \right] = \kappa_y \cdot \ln(Y_{i,t}) + \theta_{i,t} + \alpha + \varepsilon_{i,t}^m \quad (3)$$

where θ_t allows for changes in the financial technology that affects money demand independent of income. ε_t^m will be interpreted as the real money gap.

⁴ As in Gerlach and Svensson, (2003), we find that the so-called P* model has empirical support, and the “real money gap” is preferable to the “price gap” because it (i) refers directly to monetary aggregates (which is advantageous in a discussion of the predictive power of monetary aggregates), (ii) is consistent with the insight that demand for money is demand for real money, (iii) gives a precise meaning to the (often somewhat imprecise) notion of “monetary overhang,” and (iv) lends itself to comparison with the output gap.

⁵ The inclusion of proxy variables for the opportunity cost of holding money such as deposit interest rates did not show any statistically significant effect or significantly alter the coefficient on the income elasticity of money demand.

IV. DATA AND METHODOLOGY

The paper uses annual data on a panel of African countries covering a maximum time span of 1960 to 2003 with a few countries missing data for a few years. Because of data limitations for the investment time series, we only consider a subset of 19 countries (see Appendix). The data include measures of real output, total population, gross capital formation, inflation, M2 (money plus quasi-money), terms of trade, rainfall and a war index. All data are taken from the World Development Indicators except for the capital stock, rainfall and the war index. Labor is proxied by population and money is defined as “money plus quasi-money.” The real capital stock is taken from the Nehru and Dhareshwar (1995) dataset. Since data are only available from 1960 until 1990, the time series are extended using gross fixed capital formation from the WDI and a depreciation rate of 10 percent using the last available entry in the Nehru & Dhareshwar capital series (1990 or less). Rainfall data are taken from the FAO Clim 2.0 dataset, which uses gauge data from 1960 to 1998. Following Miguel, Satyanath and Sergenti (2004), a war index is built from 1960 until 2003 using the PRIO database. All country-year observations with a civil conflict in progress with at least 25 battle deaths per year are coded as ones and other observations are coded as zeros.

V. PANEL ESTIMATION

A. Estimation Technique

A key point in estimating a Phillips curve is the accurate measurement of the economy’s excess demand. We focus on two indicators; the output gap and the real money gap. The two main challenges in estimating long-term relationships in SSA are the short data time span and the frequent structural changes related to natural and man-made disasters and changes in institutions. This makes single country cointegration tests very sensitive to the different test specifications and rarely provides robust estimates of long-run relationships, which are required for computing the output and real money gaps. To illustrate the fragility of single country results, we report in the Appendix estimates for six larger African countries: Côte d’Ivoire, Ghana, Kenya, Mozambique, Nigeria, and Uganda.

As an alternative approach, we use heterogeneous panel cointegration techniques introduced by Pedroni (2000, 2004) to determine the long-run properties of output and real money demand. The interest in this approach is twofold. First, the existence of cointegrating relationships for output and the real money demand in SSA has not been documented and is interesting in its own right. Second, the group-mean FMOLS⁶ estimator from Pedroni (2000) allows heterogeneous dynamics, heterogeneous cointegrating vectors, and complete endogeneity. Intuitively, it pools the long-run information contained in the panel (thus bringing additional information to bear upon a particular cointegration hypothesis) while permitting short-run dynamics and fixed effects to be heterogeneous across different members of the panel enabling us to estimate the long-run production function and long-run real money demand operating across different SSA countries. Moreover, the technique does not produce inconsistent

⁶ Each FMOLS estimator corrects for endogeneity and for serial correlation by estimating long run covariance directly.

estimates of standard errors when regressors are endogenous as would be the case under panel OLS methods.

The systematic estimation of the production function and money demand function allows us to derive output gaps and money gaps for SSA. Using the pooled dataset of a large sample of SSA countries, we estimate equations (2) and (3), and assume that the unique cointegrating vectors estimated correspond to a stable production function (constant factor shares) and long-run money demand function (constant elasticity of money demand), respectively. We view this method as a good first approximation given the strong theoretical underpinnings and simple specification employed. In the case of the output equation, this approach allows us to conduct a simple growth accounting exercise without imposing arbitrary assumptions regarding the production process.⁷ The last step to determine potential output and long-run real money demand is to derive trend total factor productivity and changes in financial technology. This is done by smoothing the residuals of the cointegrating equations.⁸ As emphasized by Pritchett (2000), growth patterns in developing countries have been far from similar. “While some countries have [had] steady growth, others have [had] rapid growth followed by stagnation, rapid growth followed by decline or even catastrophic falls, continuous stagnation, or steady declines”. This is especially true of Sub-Saharan Africa and a single time trend may not adequately characterize the evolution of TFP in most developing countries. Hence, we will fit a polynomial of higher order (3) to capture these variations.⁹ The output gap is then defined as the difference between actual and potential output. For the long-run money demand, we allow for deregulations or changes in the financial technology that affects money demand independently of income, and we estimate $\theta_{i,t}$ by fitting a polynomial of order 3. The real money gap is the difference between actual and long-run money demand.

B. Data Properties

Before testing for panel cointegration, we need to make sure that the variables of interest have unit roots. We take advantage of the panel structure and, rather than using time series unit root tests, we report the more efficient panel unit root tests from Im, Pesaran and Shin (2002) for output, capital, labor, and real money. In accordance with previous studies, Table A3 shows that we cannot reject the null of unit-root for these variables.

⁷ This is usually the case in Growth Accounting exercises for SSA: a plausible capital share is imposed given data limitation and difficulties in estimating a robust long-run relationship (see, for example, Tahari, Ghura, Akitobi and Brou Aka (2004)). We report a decomposition of the sources of growth for Sub-Saharan countries in the Appendix.

⁸ Most other growth accounting studies estimate TFP as the change in output not explained by changes in factor inputs. Thereby, large short-term output fluctuations, which are caused by a host of other circumstances including changes in capacity utilization, are typically attributed to changes in TFP. Tahari, Ghura, Akitobi and Brou Aka (2004) provide a good overview of past studies and estimates of TFP growth for countries in Sub-Saharan Africa.

⁹ This is certainly a somewhat ad-hoc choice but it allows richer idiosyncratic individual behaviors and is no-more ad-hoc than a trend of order 1. Exploring the underlying features of each country would ultimately lead us to include time dummies and allow for occasional breaks in trends; things not so different from a higher order polynomial fit. In addition, our conclusions do not alter significantly depend on this particular choice of a cubic polynomial.

C. Measuring the Output Gap

In order to test for the null of no panel cointegration, we use the seven statistics developed by Pedroni.¹⁰ These statistics all aim at rejecting the absence of panel cointegration, but the power of each statistic varies with the sample size and the data generating process. In Table 1 we report these statistics for the null of no panel cointegration between output, capital and labor under the assumption of a constant return to scale (CRS) production function. The evidence seems mixed because only three out of the seven tests can accept panel cointegration. However, our panel data is small in N and T and in this case; the two most powerful tests are the panel ADF-stat and group ADF-stat. Since these two strongly reject the null, this is encouraging for the existence of panel cointegration and we proceed to the estimation of the cointegrating vector.

Table 1. Panel Cointegration Tests

Test:	CRS Production function 1960-2004, N=17	real money demand 1970-2004, N=19
panel v-stat	16.64**	5.71**
panel rho-stat	-1.81	-1.35*
panel pp-stat	-1.73	-2.60**
panel adf-stat	-4.8**	-2.28**
group rho-stat	-0.53	-0.61
Group pp-stat	-1.17	-2.64**
group adf-stat	-4.42**	-2.71**

Note: heterogeneous 3rd order polynomial allowed for production function, heterogeneous trend allowed for real money demand, no common time trend, (**) indicates significance at the 5% level, H₀: no heterogeneous panel cointegration

The result for the panel cointegration regression is shown in the first column of Table 2. The panel group FMOLS estimate¹¹ for the capital share is 0.28 and varies little when we change the sample size in the time or country dimension. This is remarkably close to the usual capital share of one third usually found for developed economies. Note that the results do not hinge on the constant return to scale assumption. Table A4 reports FMOLS estimates when we do not impose a CRS production function. The capital share becomes 0.27 and the labor share is 0.78, and we cannot reject that they sum to one, thereby indicating that the CRS hypothesis is reasonable.

Table 2. Cointegration Regressions

Country FMOLS estimates:	CRS production function Capital Share 1960–2004	Real money demand Income Elasticity 1970–2004
Panel group FMOLS:	0.28** (21.62)	1.02** (30.36)

Note: no common time trend, all reported values are distributed N(0,1), (**) indicates significance at the 5% level, Panel H₀: no cointegration for most countries

¹⁰ Under the alternative hypothesis, panel v statistic diverges to positive infinity. Therefore, it is a one sided test where large positive values reject the null of no panel cointegration. The remaining statistics diverge to negative infinity, which means that large negative values reject the null. Pedroni (2004) showed with Monte-Carlo simulations that with small N and T, the two tests with the most power are the panel ADF-stat and group ADF-stat while the group ρ -test has the least power of the seven tests and under-reject the null of no cointegration.

¹¹ Since the data are panel cointegrated but not necessarily cointegrated at the country level, we do not report estimates for individual countries. However, it is interesting to note that all the significant capital share estimates have plausible values ranging from 0.18 to 0.62.

Finally, we evaluate the potential output series by imposing the capital share estimate of 0.28 for each country. The output gaps are defined as the difference between true and potential output; the results are shown in Graph 5. The output gaps are typically in the range of plus or minus 0.5 percent of GDP.¹² This is smaller than other output gap measures such as the one from Coe and McDermott (1997) for Asian economies but of the same magnitude as the output gaps estimated with an HP filter ($\lambda=1600$). In Table 3, we verify that the gaps are stationary using the Im, Pesaran and Shin Z-stat and the Hadri W-stat tests.

Table 3. Stationarity Tests for Measured Gaps

		without trend	without/with trend
Y_gap	Im, Pesaran and Shin W-stat	-10.54**	-7.14**
	Hadri Z-stat	-2.79	0.10
Y_gapHP	Im, Pesaran and Shin W-stat	-11.55**	-9.67**
	Hadri Z-stat	-1.89	1.17
M_gap	Im, Pesaran and Shin W-stat	-10.65**	-7.82**
	Hadri Z-stat	-2.89	-0.45

Note: (**) indicates significance at the 5% level, H_0 W-stat: individual unit root, H_0 Z-stat: no common unit root

D. Measuring the Real Money Gap

To estimate the real money gap, we follow the same procedure as above. First we test for panel cointegration and find strong evidence in favor of panel cointegration: as shown in Table 1, we can reject the null in 6 out of 7 cases and the remaining case, the group ρ -test, has the least power. As shown in the second column of Table 2, the group mean FMOLS estimate of the money-demand income elasticity is 1.02. This is broadly in line with findings from Nachegea (2001), Jenkins (1999) and Rother (1999) who report income elasticities around unity for Uganda, Zimbabwe, and the West African monetary union.

We recover the real money gap by imposing a money demand elasticity of 1.02 for each country. As shown in Graph 7, it is economically larger than the output gap and fluctuates around plus or minus 1.5% of GDP. We verify that it is stationary by running standard stationarity tests in Table 3.

E. Phillips Curve Estimates

Now that we have recovered the output gap (2) and real money gap (3), we are ready to estimate the expectation-augmented Phillips curve (1) for Sub-Saharan Africa. To ensure

¹² Using a different capital stock series (e.g. Penn Table) or assuming a different depreciation rate does not modify substantially the results.

consistency of the estimates, we use the Panel GMM approach from Arellano and Bond (1991) with 3 lags for instruments.¹³ Table 4 shows the results.

The estimated output gap and money gaps are both economically and statistically significant in accounting for inflation in SSA. Several conclusions are worth noting. First, the coefficient on lagged inflation is always significant with a value around 0.50. Second, the coefficients for the output gap and the real money gap are always significant. Table 4, column 1 considers only the output gap while Table 4, column 2 only the real money gap. In both cases, the coefficients are significant. To answer the question of their relative importance in explaining inflation movements, we enter both variables simultaneously in Table 4, column 3. The structural output and real money gaps have a significant predictive power on inflation. The elasticities are respectively 0.19 and 0.29. Finally, using an HP-filtered measure of the output gap does not change the main conclusions; the elasticities from Table 4, column 4 are 0.23 and 0.29. Recall that real money gap fluctuations were found to be around twice as large as output gap variations. This means that for Sub-Saharan countries, the real money gap plays a larger role in the inflation process. This is not surprising as demand stimuli are often financed through “excess” monetary financing.

One possible criticism to a Phillips curve in developing countries is the fact that potential output is less meaningful when a large proportion of output is accounted for by primary commodities whose production is supply-determined. Hence, our output gap measure could be a measure of supply shocks and not demand fluctuations. In regression (5), we control for exogenous shocks likely to have an impact on inflation: changes in the terms of trade, rainfall, war, and the CFA Franc devaluation.¹⁴ The conclusions remain unaltered, indicating that our gap measures capture demand fluctuations and not supply shocks.¹⁵ Finally, as emphasized by Faal (2005) for the case of Mexico, it is important to verify the stability of the relationship when testing for a Phillips curve. We made the implicit assumption that the relationship between the gaps and inflation was stable during the sample period. But this is unlikely to be exactly the case for African economies that have experienced sharp structural changes or shifting expectations since the seventies. However, restricting our sample to 1980–2004 in Table 4, column 6 does not change the results.

To examine the economic significance of our estimates, it is interesting to calculate the cumulative effect that a positive output gap or real money gap has on inflation. Using the estimates from regression (5), we find that a 1 percent increase in the output gap will contribute to a total excess inflation of 0.5 percentage points over the future. A 1 percent increase in the

¹³ With dynamic panels, fixed effects (FE) estimators are inconsistent with a bias in $1/T$. However with $T=45$ ($N=17$), the bias is likely to be small so we report FE estimates in the Appendix. While Pesaran and Smith (1995) shows that fixed effects, instrumental variables or GMM estimators can be inconsistent and produce misleading estimates of the average values of the parameters in dynamic panel data models when T is large and the slope coefficients are not identical, the sample dimensions and diagnostics support the GMM approach employed.

¹⁴ For most African countries, the agricultural sector represents roughly 40 percent of GDP. A drought would lead to an increase in prices independent of demand inflationary pressures.

¹⁵ The elasticities are slightly bigger but this is partly due to the shorter sample size 1970–1998 due to missing rainfall data.

real money gap will increase future inflation by a total 0.6 percentage points. Since the output and real money gaps are in the order of magnitude of 1 percent of GDP, a 1 percent increase in the gap is only a minor fluctuation in GDP but a fluctuation with a far from negligible impact on inflation.

Table 4. Phillips Curve Panel GMM Estimates

Dependent variable:	Π	Π	Π	Π	Π	Π
Sample	1970-2003	1970-2003	1970-2003	1970-2003	1970-1998	1980-2003
Regression	(1)	(2)	(3)	(4)	(5)	(6)
Estimation	GMM	GMM	GMM	GMM	GMM	GMM
Π ₋₁	0.53*** (5.74)	0.48*** (6.90)	0.51*** (7.79)	0.52*** (8.57)	0.41*** (6.06)	0.53*** (6.66)
Y _{gap-1}	0.28** (2.48)	--	0.19*** (3.35)		0.29*** (3.51)	0.30*** (4.216)
Y _{gapHP-1}	--	--	--	0.23*** (2.97)	--	--
M _{gap}	--	0.34*** (4.47)	0.29*** (3.91)	0.29*** (3.99)	0.37*** (3.65)	0.33*** (3.11)
ΔTOT	--	--	--	--	-1.84e-4 (0.19)	--
Controls	NO	NO	NO	NO	YES	YES

Note: 1st difference(AB 1-step) GMM procedure, White-period SE (d.f. corrected), t-stat in parentheses, 3 lags used for instruments

F. Asymmetry in the Phillips Curve

A final policy question is whether there is any asymmetry in the Sub-Saharan Phillips curve. For example, in the case of a positive asymmetry in which inflation responds more to a positive gap than to a negative gap, allowing the economy to produce in excess of its potential will be more costly because a larger negative gap (whether output or money) will be needed to rein in inflationary pressures.

To test for asymmetry, we specify a simple asymmetric Phillips curve as follows:

$$\pi = \alpha_{\pi}\pi_{-1} + \alpha_y y_{gap,-1} + \alpha_{y^{pos}} y_{gap,-1}^{pos} + \alpha_m m_{gap} + \alpha_{m^{pos}} m_{gap}^{pos} + \varepsilon \quad (4)$$

with y^{pos} equal to the output gap when the latter is positive but equal to zero otherwise. m^{pos} is defined in a similar fashion.

As can be seen in Table 5, we do not find any significant evidence of asymmetry. However, we do find opposite signs for the money gap and the output gap, 0.13 and -0.19. Although the difference is not statistically significant, this could suggest that the money gap plays a more important role in inflation buildup than the output gap does, and that conversely bringing down high inflation would require a larger negative output gap. This is hardly surprising and stresses further the danger of a lax monetary policy.

Table 5. A Simple Asymmetric Model

Dependent variable:	Π	Π	Π
Sample	1970-2003	1970-2003	1970-2003
Regression	(7)	(8)	(9)
Estimation	GMM	GMM	GMM
Π_{-1}	0.51*** (5.24)	0.46*** (6.36)	0.55*** (8.57)
Y_gap ₋₁	0.41** (2.25)	--	0.34** (1.99)
Y_gap ₋₁ pos	-0.29 (1.32)	--	-0.19 (0.63)
M_gap	--	0.24*** (2.66)	0.24*** (2.81)
M_gappos	--	0.13 (0.77)	0.13 (0.89)
SE of reg.	0.15	0.13	0.14

Note: 1st difference(AB 1-step) GMM procedure, White-period SE (d.f. corrected), t-stat in parentheses, 3 lags used for instruments

VI. CONCLUSION

In this paper, we provide a first estimate of an augmented Phillips curve for Sub-Saharan Africa. We examine the determination of inflation in SSA, particularly the role of the output gap and the real money gaps. The short data time span imposed by African data severely limit single country analysis and we use panel cointegration techniques to estimate the structural gaps. This also allows us to conduct a consistent growth accounting exercise across SSA, giving a capital share of 0.28, which is remarkably close to the capital share of one third usually found for developed economies. In addition, the panel money demand estimation reports a money demand elasticity around unity, confirming previous single country studies in SSA.

We present strong evidence that the structural gaps contain considerable information regarding the evolution of inflation. Interestingly, in SSA, the real money gap plays a larger role in inflation processes than the output gap. This highlights the importance of the money gap as an indicator of inflationary pressures, alongside the output gap emphasized for developed countries. Moreover, the evidence suggests that targeting monetary aggregates in SSA can provide an effective anchor to control inflation as practiced by a number of countries in the region, especially in the context of IMF-supported programs. We do not find any significant evidence of an asymmetric Phillips curve relationship, although excess money seems to have a larger impact on inflation buildup than excess output does.

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APPENDIX

Table A0: Country list¹⁶

Botswana	Niger
Cameroon	Nigeria
Cote d'Ivoire	Rwanda
Ethiopia	Senegal
Ghana	Sierra Leone
Kenya	Swaziland
Madagascar	Uganda
Malawi	Zambia
Mali	Zimbabwe
Mozambique	

Table A1: ADF tests for variables in levels without/with trend and with SIC for lag length

all variables in log	Côte d'Ivoire	Ghana	Kenya	Mozambique	Nigeria	Uganda
Y	-3.23*/-1.55	1.10/-0.53	-3.29*/-0.04	3.14/-0.52	-0.78/-2.46	0.14/-1.00
K (est2)	-2.05/-0.39	-0.92/-2.03	-2.21/-0.78	-3.02**/-2.68	-2.52/-2.68	-0.15/-1.17
L	-1.42/-1.78	-0.38/-1.89	-2.40/-0.96	-0.22/-3.18	-2.69*/-1.34	1.28/-1.66
M2r	-3.11**/-2.74	0.29/-0.65	-2.03/-1.82	-0.51/-1.77	-1.67/-1.74	0.93/-2.07

Note: (*) indicates significance at the 10% level and (**) at the 5% level, H_0 : series has a unit root

Table A2a: Production function

OLS	Côte d'Ivoire	Ghana	Kenya	Mozambique	Nigeria	Uganda
K	0.24 (0.04)	0.32 (0.08)	0.54 (0.10)	0.19 (0.13)	0.16 (0.04)	0.54 (0.02)
L	0.51 (0.03)	0.79 (0.07)	1.05 (0.03)	2.37 (0.17)	0.84 (0.06)	0.40 (0.04)
ADF t-test of residual	-3.30	-2.15	-2.04	-2.26	-2.06	-1.82

Note: SE in parentheses, ADF t-test: (*) and (**) indicates significance at the 10 (t=3.74) and 5% level, H_0 : no cointegration

Table A2b: Real money demand

OLS; time trend, controls (tot, war)	Côte d'Ivoire	Ghana	Kenya (control for tot)	Mozambique	Nigeria (control for tot)	Uganda
M2r	1.46*** (0.20)	3.77*** (0.25)	0.61*** (0.12)	1.36* (0.76)	0.89*** (0.21)	3.23*** (0.93)
ADF t-test of residual	-3.27*	-3.32*	-4.41**	-3.42*	-4.19**	-2.90

Note: SE in parentheses, (*) and (**) indicates significance at the 10 (t=3.04) and 5% level, H_0 : no cointegration

¹⁶ We removed South-Africa from the sample because it is considered a middle-income country that differs substantially from the rest of the developing SSA countries.

Table A3: Im, Pesaran and Shin W-stat without/with trend

all variables in log	levels	First-order difference
Y	2.22/-0.06	-17.19**/-16.90**
K (est2)	-0.34/3.17	-6.10**/-6.87**
L	5.83/2.17	-6.65**/-3.83**
M2r	-0.65/-0.35	-17.78**/-16.70**
Π	-6.24**/-4.91**	--
tot	-4.95**/-3.93**	--

Note: (**) indicates significance at the 5% level, H_0 : individual unit-root process

Table A4: FMOLS regressions for production function 1960-2004

Country FMOLS estimates:	K (t-stat)	L (t-stat)
Panel group FMOLS:	0.27** (17.40)	0.78** (28.81)

Note: no common time trend, all reported values are distributed $N(0,1)$, (**) indicates significance at the 5% level, H_0 : no cointegration for most countries

Table A5: Phillips curve panel OLS estimates

Dependent variable:	Π	Π	Π	Π
Sample:	1970-2003	1970-2003	1970-1998	1980-2003
Equation	(1)	(2)	(3)	(5)
Estimation	FE	FE	FE	FE
Π_{-1}	0.65*** (9.28)	0.66*** (9.50)	0.50*** (9.10)	0.67*** (8.59)
Y_gap ₋₁	0.23** (2.86)	--	0.19** (2.45)	0.29*** (2.99)
Y_gapHP ₋₁	--	0.29*** (3.45)	--	--
M_gap	0.30*** (4.03)	0.29*** (4.21)	0.34*** (3.49)	0.33*** (3.35)
Δ TOT	--	--	2.27E-5 (0.05)	--
Controls (war, devaluation)	NO	NO	YES	YES
Adj R ²	0.63	0.63	0.66	0.67
SE of reg.	0.10	0.10	0.10	0.11

Note: t-stat in parentheses, White-period SE

Time Series Analysis for 6 Countries:

To introduce the methodology and get an order of magnitude, we present a simple time series analysis including six larger African countries: Côte d'Ivoire, Ghana, Kenya, Mozambique, Nigeria and Uganda. However, these results are based on short data time span and difficult to interpret.

Data properties and gaps estimation

We conduct ADF tests to determine the order of integration of the variables of interest: output, capital, labor and real money. Table A1 shows the results. Except for a few cases we cannot reject the null of a unit-root. Hence we take the data to be non-stationary and proceed to test for cointegration.

We estimate the two equations by OLS and test for stationary of the residuals using adjusted critical values. Table A2a and A2b reports the results. Table A2a reports ADF tests of the residual for a Cobb-Douglas production function. There is no strong evidence of a long-run relationship as we cannot reject

the null of no cointegration in all cases.¹⁷ In two cases, Mozambique and Kenya, the coefficient estimates are unrealistic. Again, the difficulty to control for major structural changes and the short data span render any estimation very delicate. Table A2b reports cointegration tests for a long-run real money demand. We can reject the null of no cointegration at 10% in 5 out of 6. The last case, Uganda, is almost significant at 10%. However, the coefficient estimates are somewhat surprising for Ghana and Uganda.

The absence of cointegration for output makes a regression with the structural output gap on the left-hand side spurious and we will therefore only test for a Phillips curve with HP filtered output gaps and structural money gap.

Phillips curve estimates

Table A7 shows the results for the Phillips curve regression for our six countries. Lagged inflation is always significant with an average value of around 0.5. The real money gap is significant in 5 out of 6 cases with a mean of 0.4. Since all variables are in logs, we can interpret the coefficients as elasticities, i.e. a 1% deviation from long-run money demand leads to a significant and positive output deviation ranging from 0.28% to 0.54%. However, we find no evidence that the output gap has any predictive power for future inflation.

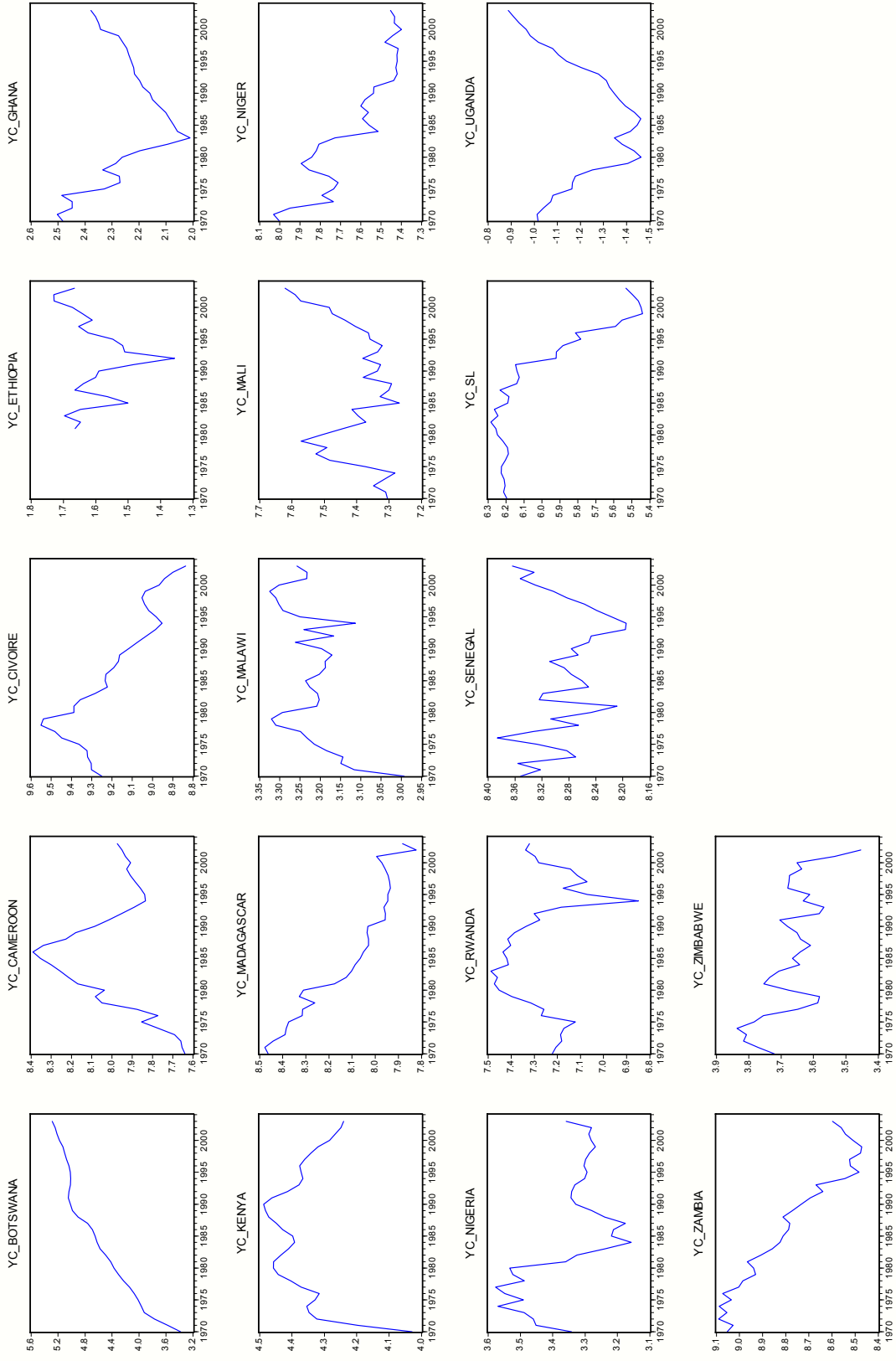
Table A6: Phillips curve regressions

Dependent variable: Π	Côte d'Ivoire	Ghana	Kenya	Mozambique	Nigeria	Uganda
Sample:	1970-2003	1970-2002	1970-2003	1988-2002	1970-2003	1970-2003
Estimation	OLS	OLS	OLS	OLS	OLS	OLS
Π_{1t}	0.49** (3.95)	0.26** (4.99)	0.58** (3.17)	0.77** (7.06)	0.43** (3.32)	0.62* (1.60)
Y_gapHP_{1t}	0.11 (0.64)	-0.18 (-0.53)	0.56* (2.14)	0.29 (0.44)	0.26 (1.31)	1.94 (0.81)
M_gap	0.08 (0.98)	0.54** (6.45)	0.31** (2.14)	0.28* (1.59)	0.35** (4.37)	0.53** (2.18)
Adj R^2	0.44	0.86	0.42	0.62	0.56	0.79

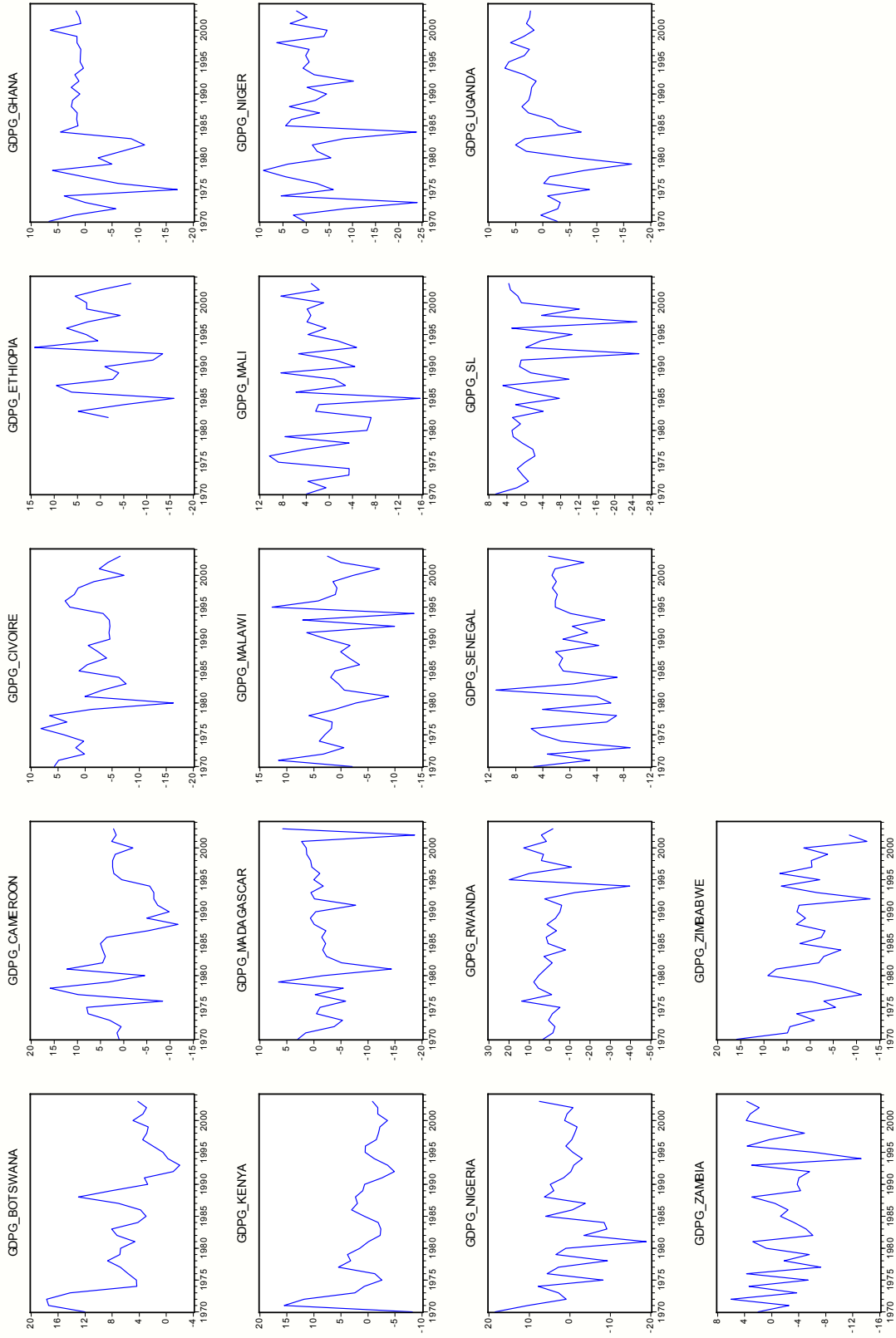
Note: t-stat in parentheses, White SE

¹⁷ We also used Johansen cointegration tests and came to the same conclusions. The cointegrating vector estimates were also very sensitive to the number of lags used and the time period considered. This further illustrates the fragility of an eventual cointegration relationship.

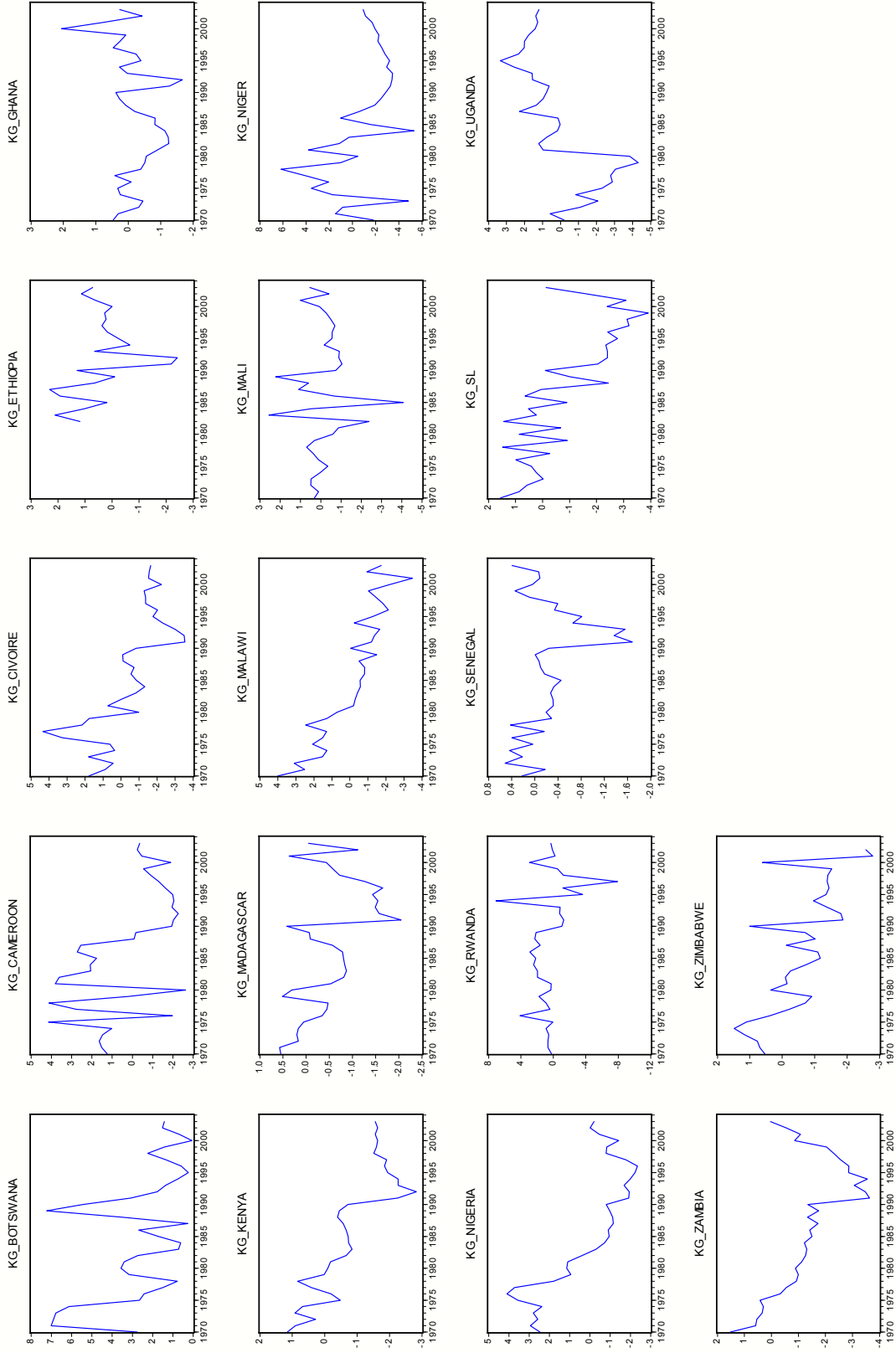
Graph 1: Output per capita:



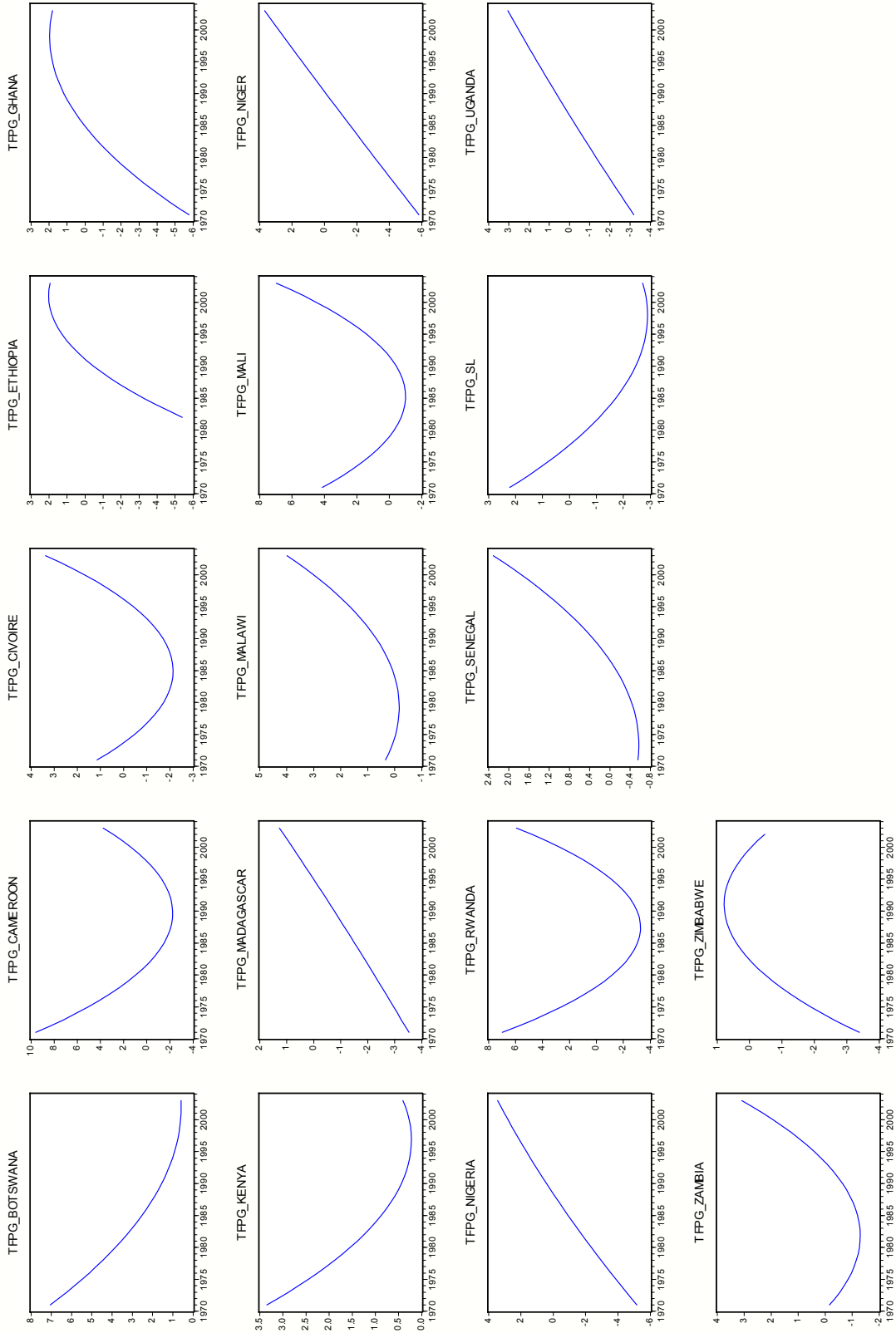
Graph 2: Output per capita growth (in %):



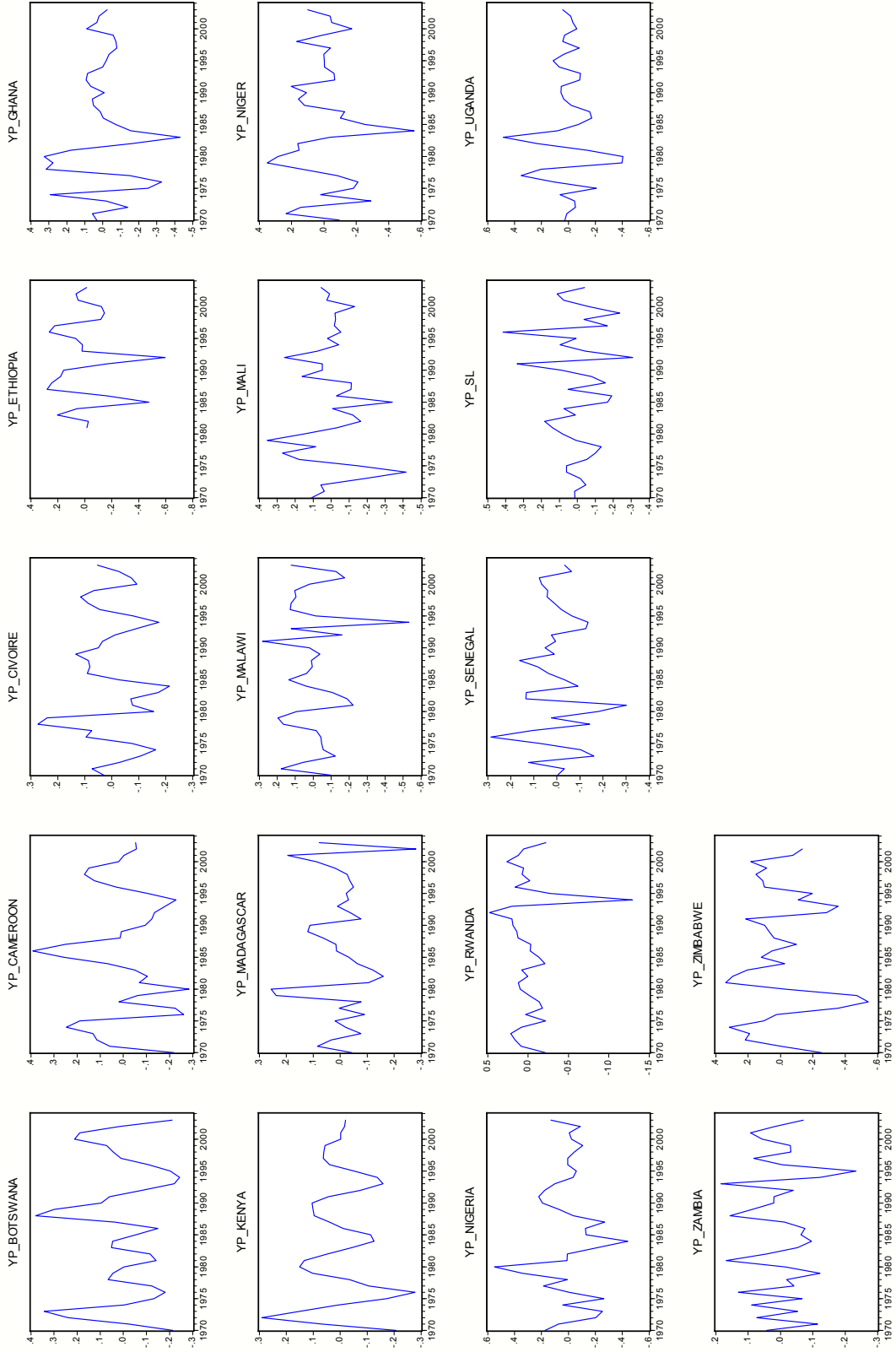
Graph 3: Contribution of capital to growth (in %):



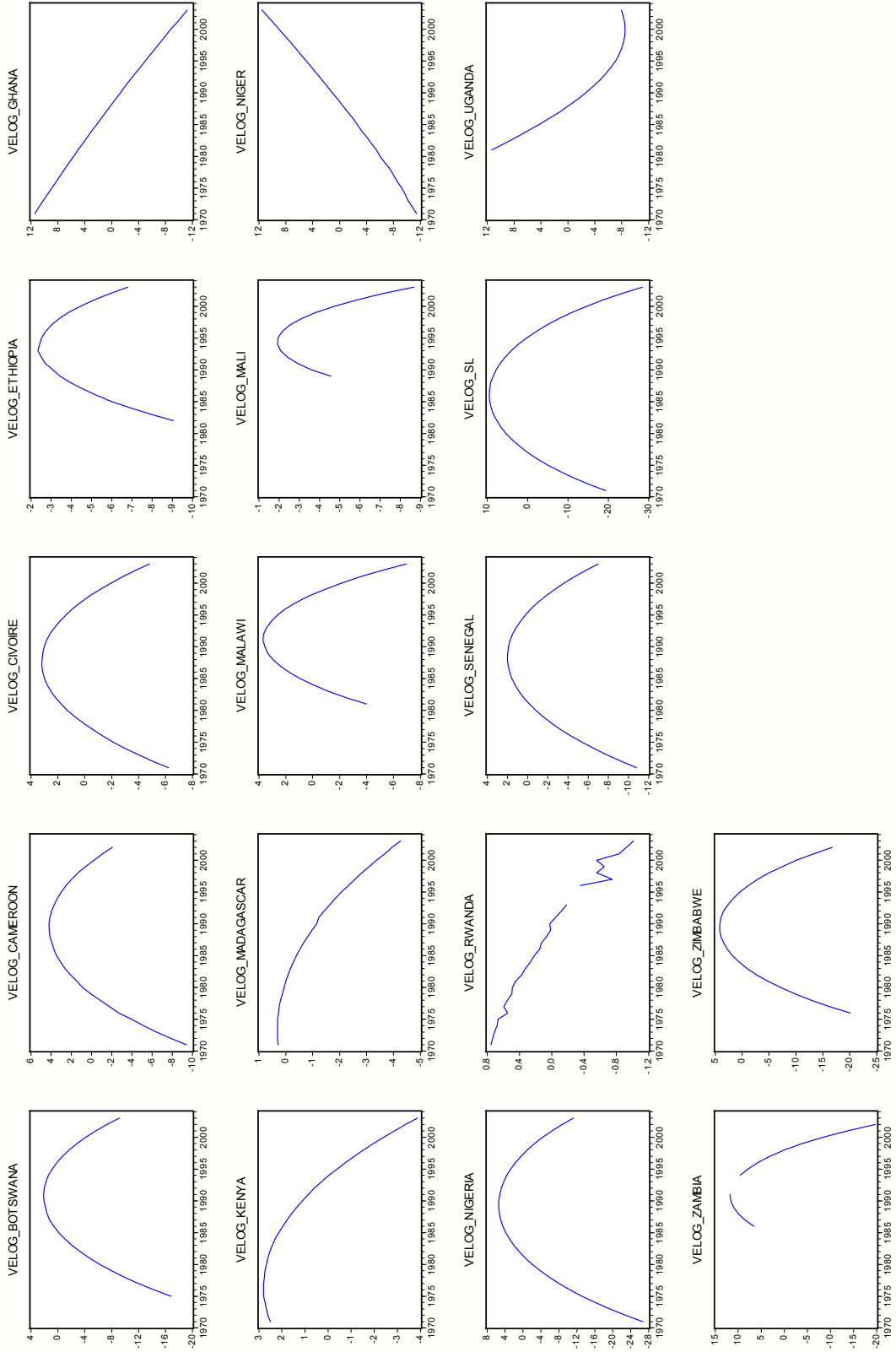
Graph 4: Contribution of smoothed Solow residual to growth (in %):



Graph 5: Output gap (in percent of GDP):



Graph 6: Changes in velocity (in %):



Graph 7: Real money gap: (in percent of GDP)

