

Прикладная эконометрика, 2016, т. 41, с. 5–23.
Applied Econometrics, 2016, v. 41, pp. 5–23.

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Threshold effects of inflation on economic growth in selected African regional economic communities: Evidence from a dynamic panel threshold modeling

The objective of this study is to estimate inflation threshold and examine its impact on the inflation-growth nexus in selected African regional economic communities. While a number of empirical studies exist in this area for developing countries, they bundle up countries from Asia, Africa and Latin America which do not have the same inflation experiences. This study therefore focuses on Africa. However, since African regional groupings themselves have different inflation experiences, non-linearity in the relationship between inflation and growth is explored within each grouping separately. The study uses dynamic panel threshold modeling recently suggested by Kremer et al. (2013) which extends the non-dynamic panel threshold model of Hansen (1999) and the cross-sectional threshold model of Caner and Hansen (2004). The results indicate that the estimated inflation threshold is different across the regional economic communities. Nonlinearity in inflation-growth nexus seems to hold in CEMAC, COMESA and SADC while it is questioned in WAEMU and WAMZ. For CEMAC, COMESA and SADC, the findings indicate that inflation above the threshold is harmful to growth. Some correlations are established in this study but further analysis is needed to suggest a policy.

Keywords: inflation threshold; growth; dynamic panel threshold regression; Africa.

JEL classification: C23; O40; E31.

1. Introduction

While the classic view is that inflation is generally a bad thing since it wastes resources (Altig, 2003), the relationship between inflation and growth is traditionally linear; it is either positive or negative depending on whether money is a substitute for capital (Mundell, 1965; Tobin, 1965) or complementary to capital (Stockman, 1981; Fischer, 1983). The latter supports a negative impact of inflation on growth and the former upholding a positive impact. In contrast, Fischer (1993) suggests that the relationship between inflation and growth is rather non-linear; the relationship is positive below a certain threshold of inflation, and negative above it.

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The primary objective of most central banks is to control inflation by keeping it low so as to mitigate or altogether eliminate its direct and indirect adverse effects on the economic activity and growth. In addition, economists often say that inflation is harmful to growth when it is too high (Friedman, 1977; Fischer, Modigliani, 1978). The question is, how low an inflation level is too low or how high is too high? Moreover, African countries in their regional economic communities have set convergence criteria concerning inflation [COMESA (5%), EAC (5%), SADC (3%), CEMAC (3%), WAEMU (3%) and WAMZ (single digit)]²; one would wonder how optimal these targets are. At which level should monetary authorities in these regions set inflation to avoid its adverse effects on growth? This is the question explored in this study. This study seeks to explore nonlinearity in the relationship between inflation and growth in five African regional economic communities, namely CEMAC, COMESA, SADC, WAEMU and WAMZ. However, as Kremer et al. (2013) point out, the established nonlinear relationship between inflation and growth does not necessarily reflect causality but rather correlation.

Some studies have tried to explain nonlinearity in the relationship between inflation and economic growth. Using the «adverse selection mechanism» in credit market, Choi et al. (1996) explain how inflation affects positively growth unless it exceeds some threshold level. Their idea is that in a financial market, there are borrowers and lenders where the financial system plays the role of channeling funds from lenders to borrowers. They argue that if inflation increases, it discourages the lenders since the real rate of return on assets is reduced and has an effect of reducing funds available for lending. At the same time, the rise in inflation encourages the borrowers and there will be more people wanting to borrow, among them new borrowers who are just profiting the situation (who were not initially interested in borrowing), and have therefore higher default risk. This creates the problem of adverse selection for financial institutions called credit market rationing, since banks will not provide credits for new borrowers who have higher default, hence fewer loans are given. Consequently, an increase in inflation causes lower economic growth. However, when inflation is low, Choi et al. (1996) claim that an increase in inflation will not lead to adverse selection mechanism but instead Mundell–Tobin effect will take place causing substitution between money and capital. Economic growth will therefore be enhanced. The bottom line is that for low levels of inflation, the model shows that inflation promotes growth but for high levels of inflation, inflation is detrimental to growth because of credit rationing.

Examining the impact of inflation threshold on economic growth has been an area of considerable research using different methodologies in the past decades. Sarel (1996), using panel data on 87 developed and developing countries finds a threshold level of inflation at 8%. Ghosh and Phillips (1998) on a larger sample than the one used by Sarel (1996), find a threshold level of inflation of 2.5% while Khan and Senhadji (2001) find a threshold inflation of 1% for industrial countries and 11% for developing countries. Drukker et al. (2005), using a panel data model estimated a threshold inflation at 19.16% for non-industrialized countries and two threshold points at 2.57% and 12.61% for industrial countries. Bick (2010), on a balanced panel of 40 developing countries using non-dynamic panel threshold regression of Hansen (1999) finds a threshold inflation of 19.16% with no regime intercepts and 12.03% by allowing regime intercepts. Most recently, Ibarra and Trupkin (2011) using Panel Smooth Transition Regression find a threshold inflation of 4.1% for industrial countries and 19.1% for non-industrial countries. In both groups of countries, the impact of inflation and growth is negative in both inflation regimes but statistically significant only in high infla-

² The description of these regional economic communities are in Table A1 (in Appendix).

tion-regime (when inflation is above the threshold). Seleteng et al. (2013) also using Panel Smooth Transition Regression on SADC countries found a threshold inflation at 18.9%. The effect of inflation is negative in both regimes but only statistically significant above the inflation threshold.

It is important to note that most of the panel studies in this area use either the non-dynamic panel threshold regression of Hansen (1999) or non-dynamic Panel Smooth Transition Regression (PSTR) of Gonzalez et al. (2005). However, Kremer et al. (2013) argue that the existing studies using panel data on the threshold effects of inflation on growth might have some shortcomings since initial income as an important variable in growth models is either not included among the control variables or when included the endogeneity problem it causes is not taken into account (see for instance, (Khan, Senhadji, 2001; Drukker et al., 2005; Bick, 2010; Seleteng et al., 2013)), a result of which can be misleading in the threshold estimation. Kremer et al. (2013) therefore propose a methodology, dynamic panel threshold regression, which addresses that potential problem by building on Hansen (1999), Caner and Hansen (2004). Applying dynamic panel threshold regression in analyzing the threshold inflation effect on growth, their findings reveal a threshold inflation of 2.53% for industrial countries and 17.22% for non-industrial countries. For industrial countries, the relationship is significantly positive below the threshold and significantly negative above the threshold. However for non-industrial countries, the relationship is negative in both regimes but statistically significant only above the threshold.

This study follows Kremer et al. (2013) and adopts dynamic panel threshold regression in estimating the threshold level of inflation and analyzing its impact on inflation-growth nexus in Africa. While the existing studies on this topic on developing countries combine countries from Asia, Africa, Latin America (see for instance (Khan, Senhadji, 2001; Drukker et al., 2005; Bick 2010; Ibarra, Trupkin, 2011; Kremer et al., 2013)), this study focuses only on Africa. In fact, the bundling up of countries which do not have the same inflation experiences can be misleading when estimating the inflation threshold. In addition, as Table A2 (in Appendix) shows, African regional groupings within themselves have different inflation experiences with COMESA, SADC and WAMZ exhibiting highest average inflation rates as compared to CEMAC and WAEMU which experienced relatively lower inflation rates. With such disparities in the levels of inflation across those groupings, this study explores nonlinearity in the relationship between inflation and growth within each economic grouping separately. In addition, while some previous studies determine exogenously the level of inflation threshold (see for instance (Fischer, 1993; Bruno, Easterly, 1998)), the level of inflation threshold is endogenously determined in this study.

The rest of the paper is organized as follows. Section 2 gives some background information on inflation, growth and economic development in the selected African regional economic communities. Section 3 highlights the methodology and data used. Section 4 presents the empirical results and discussion. Section 5 makes comparison with other previous studies' findings and section 6 gives the concluding remarks.

2. Inflation, growth and economic development in African regional economic communities

In the recent years, the degree of economic integration in Africa has increased; however countries within the regional economic communities (i. e. CEMAC, COMESA, SADC, WAEMU, WAMZ, etc.) are still divergent in terms of the level of income per capita, inflation rate, eco-

conomic growth, etc. As Table A2 indicates, inflation experiences have been different across the five regional economic communities considered, with CEMAC and WAEMU experiencing lower inflation rates than COMESA, SADC and WAMZ. Over the sample period, the average inflation rate for CEMAC is 3.3% with the lowest average inflation rate observed in Central African Republic (3.2%) while the highest was recorded in Cameroon (6.3%). For WAEMU, the average inflation is 5.3%, with the highest average inflation found in Guinea Bissau (13.3%) and the lowest in Niger (−0.002%). In fact, apart from Guinea Bissau, the rest of the countries in WAEMU have an average inflation around 1% while Mali and Niger have negative inflation rates. For COMESA, the average inflation rate is 19.6%, the highest average is found in Democratic Republic of Congo (85.3%), followed by Sudan and Uganda with average inflation rate respectively of 27.2 and 25.1%, and while the lowest average inflation is found in Libya (3.3%). For SADC, the average inflation rate is 41.8%, with the highest rate recorded in Angola (313.4%), while the lowest is in Seychelles (6.9%). For WAMZ, the average inflation rate was 13.8% with the highest inflation found in Ghana (24.1%) and the lowest in Guinea (1.7%).

Differences in inflation across these economic communities can be explained by the difference in monetary policy regimes pursued. Countries in CEMAC and WAEMU for example belong to the CFA³ zone with a common currency, CFA franc, which is pegged to the Euro (International Monetary Fund, 2013). Monetary policy in these regions, CEMAC and WAEMU, is therefore conducted by the regional respective central banks (Banque des États de l'Afrique Centrale, BEAC, and Banque Centrale des États de l'Afrique de l'Ouest, BCEAO) with a fixed exchange regime in order to keep inflation low (International Monetary Fund, 2005, 2009). For COMESA, SADC and WAMZ, apart from Ghana⁴ and South Africa⁵, which are pursuing an inflation-targeting regime, the rest of the countries are following a monetary targeting regime by managing a floating exchange rate.

Similarly, growth experiences have also been different across these communities. Over the sample period, growth of real per capita GDP varied from one community to the other with an average growth rate of 2.5% for CEMAC, 0.9% for COMESA, 1.5% for SADC, 0.4% for WAEMU and 0.1% for WAMZ. The highest mean growth of per capita GDP in CEMAC was recorded in Equatorial Guinea (12.2%) and the lowest in Central African Republic (−1.2%). For COMESA, the highest mean growth is found in Mauritius (4.1%) while the lowest is found in Democratic Republic of Congo (−3.0%). The highest mean growth in SADC is found in Botswana (4.7%) and the lowest in Democratic Republic of Congo (−3.0%). In WAEMU, Mali recorded the highest average growth (2.3%) and Niger the lowest (−1.4%). For WAMZ, Nigeria is leading with an average growth rate of 1.4% while Liberia has the lowest growth rate (−2.6%).

Similarly, the level of economic development is also quite different across the five regional economic communities as shown by the level of real GDP per capita (see Table A5 in Appendix). For the period 1980–2011, CEMAC has the highest average real GDP per capita (USD 2776.7), followed by SADC (USD 2281.4) and COMESA (USD 1817.2). WAMZ has the lowest real GDP per capita (USD 445.6). Within each regional community, the level of development seems to be diverse across countries. For CEMAC for instance, the level of real GDP per

³ CFA stands for Communauté Financière Africaine (African Financial Community) in West African CFA zone and Coopération financière en Afrique centrale (Financial Cooperation in Central Africa) in Central African CFA zone.

⁴ Ghana adopted inflation-targeting framework for its monetary policy in May 2007.

⁵ Inflation-targeting framework in South Africa started in February 2000.

capita in Gabon is USD 7755.3 (the highest in CEMAC) while for Central African Republic, it is only USD 405.3 (the lowest in CEMAC). The same observation can be made for COMESA and SADC where Seychelles has a real GDP per capita of USD 9980.9 while Ethiopia, Burundi and Democratic Republic of Congo have USD 157.5, USD 181.9 and USD 208.7 respectively. In WAEMU and WAMZ however, although the levels of real GDP per capital are not the same across countries, they are at least comparable. According to Thanh (2015), differences in initial output conditional characteristics may have an impact on the relation between inflation and growth.

Figure 2 presents the panel series for growth, inflation⁶ and initial income⁷ for CEMAC, COMESA, SADC, WAEMU and WAMZ. There seems to be no trend in the panel series, but fluctuations are observed especially for growth and inflation. The link between these variables is not easy to detect but for some observations, one can see that an increase in inflation is associated with an increase in growth while for some other observations, an increase in inflation is associated with a decrease in growth. Similar observation can be made for the relationship between initial income and growth.

3. Methodology and data

Dynamic Panel Threshold Regression initiated by Kremer et al. (2013) is adopted in this paper to estimate the inflation threshold level and to examine its impact on the relationship between inflation and long-run growth in African regional economic communities.

In order to examine the impact of the inflation threshold on the relationship between inflation and economic growth (growth rate of Real GDP per capita) by taking into account some control variables including initial income (lagged Real GDP per capita) which is an endogenous variable, we use the Dynamic Panel Threshold Model initiated by Kremer et al. (2013) which is an extension of the Non-Dynamic Panel Threshold Model of Hansen (1999) and the cross-sectional threshold model of Caner and Hansen (2004).

The Panel Threshold Model estimated is written as follows:

$$y_{it} = \mu_i + \beta_1' z_{it} I(q_{it} \leq \gamma) + \beta_2' z_{it} I(q_{it} > \gamma) + \varepsilon_{it}, \quad (1)$$

where $i = 1, \dots, N$; $t = 1, \dots, T$; μ_i are country individual effects; y_{it} is the dependent variable; q_{it} is the threshold variable; γ is the common threshold value; $I(\cdot)$ is the indicator function; z_{it} is a vector of the control variables including exogenous variables z_{1it} which are uncorrelated with the error term ε_{it} , and endogenous variables z_{2it} , correlated with the error term ε_{it} . The error term ε_{it} is identically and independently distributed, that is $\varepsilon_{it} \sim (0, \sigma^2)$. In estimating the model (1), instrumental variables x_{it} (including z_{1it}) are needed in GMM estimation. In this dynamic model, the individual effects are eliminated using the forward orthogonal deviations transformation suggested by Arellano and Bover (1995) which ensures that the error terms are not autocorrelated and that the cross-sectional threshold model of Caner and Hansen (2004) is applied to the dynamic panel model. Basically the procedure of estimation goes as follows.

⁶ This is a semi-log transformed inflation.

⁷ Initial income is here captured by the logarithm of the lagged real GDP per capita.

First, the endogenous variable z_{2it} is estimated as a function of instruments x_{it} and the predicted value of $\hat{z}_{2it}$ is obtained. *Second*, equation (1) is estimated using OLS by substituting z_{2it} with the predicted value $\hat{z}_{2it}$ from the first regression. The residual sum of squares derived from this equation is noted as $S(\gamma)$, where γ is the common threshold value to be estimated. The estimated optimal threshold value $\hat{\gamma}$ is such that the residual sum of squares is minimum: $\hat{\gamma} = \text{argmin}_n S_n(\gamma)$. *Third*, after getting the estimated threshold value $\hat{\gamma}$, the regression slope coefficients are obtained by GMM using the instruments and the estimated threshold $\hat{\gamma}$.

Applying Dynamic Panel Threshold Model in equation (1) to the analysis of the impact of inflation threshold on long-run economic growth gives the following threshold model:

$$gpcgdp_{it} = \mu_i + \beta_1 \tilde{\pi}_{it} I(\tilde{\pi}_{it} \leq \gamma) + \delta_1 I(\tilde{\pi}_{it} \leq \gamma) + \beta_2 \tilde{\pi}_{it} I(\tilde{\pi}_{it} > \gamma) + \alpha z_{it} + \varepsilon_{it}, \quad (2)$$

where μ_i are country individual effects, $gpcgdp_{it}$ (growth rate of real GPD per capita) is the dependent variable, $\tilde{\pi}_{it}$ (inflation) is the threshold variable and regime-dependent regressor, z_{it} is a vector of the regime-independent regressors containing the endogenous variable, z_{2it} [initial income captured by lagged real GDP per capita $pcgdp_{it-1}$] and exogenous variables, z_{1it} and δ_1 is the regime intercept common to all cross-sections. According to (Bick, 2010), estimating the threshold model without including the regime intercept if it is present in the data generating process can lead to a bias proportional to δ_1 since orthogonality of the regressors is not preserved anymore. β_1 gives the marginal impact of inflation on long-run growth when inflation is below the threshold and β_2 presents the marginal impact of inflation on long-run growth when inflation is above the threshold. Since the regression slope coefficients are obtained using GMM estimation, as in (Arellano, Bover, 1995), the lags of the dependent variable $pcgdp_{it-2}, pcgdp_{it-3}, \dots, pcgdp_{it-p}$ are used as instruments.

The analysis in this study is based on unbalanced panels of African regional economic communities, CEMAC, COMESA, SADC, WAEMU and WAMZ for different periods depending on data availability. Sample of countries for each grouping and periods considered are in Table A3 of the Appendix. Following (Khan, Senhadji, 2001; Drukker et al., 2005; Ibarra, Trupkin, 2011; Kremer et al., 2013), also as cited in a number of empirical growth literature, we use five-year averages of the data. According to (Khan, Senhadji, 2001), using five-year averages of data has an advantage because it helps to smooth out business cycle fluctuations and hence focus on the medium and long-term relationship between inflation and growth. With five-year averaged data, time dimension for each country of the sample is reported in Table A4 of the Appendix along with average inflation and average growth.

In examining the threshold inflation effect on economic growth, for purposes of comparison with other previous studies, we use as control variables population growth rate, investment-GDP ratio, initial income level measured as GDP per capita from the previous period, openness to trade measured as the ratio of the sum of exports and imports to GDP, the growth rate of the terms of trade measured by the ratio of exports over imports, the standard deviation of the terms of trade and the standard deviation of openness. The list and definition of variables used are in Table 1.

In order to make the distribution of the five-year average of inflation much more symmetric, the following semi-log transformation (since log transformation is not possible for negative inflation rates) of inflation (see equation (3)) is used as in (Khan, Senhadji, 2001; Drukker et al.,

2005; Kremer et al., 2013). Indeed as Figure 1 shows, apart from CEMAC, the distribution of the five-year average of inflation before semi-log transformation is highly skewed while the semi-log transformed inflation is much more symmetric.

Table 1. List and definition of variables

<i>gpcgdp</i>	Five-year average of annual growth rate of Real GDP per capita in constant 2005 prices
$\tilde{\pi}$	Five-year average of semi-log transformed inflation (annual percentage change of the CPI Index)
<i>initial</i>	Five-year average of one period-lagged real GDP per capita in 2005 constant prices
<i>popgr</i>	Five-year average of annual growth rate of population
<i>inv</i>	Five-year average of the investment GDP ratio (percentage of GDP)
<i>tot</i>	Five-year average of annual percentage change in the terms of trade (terms of trade measured by exports divided by imports)
<i>open</i>	Five-year average of log of openness, where openness is measured by the GDP ratio of the sum of exports and imports
<i>stdtot</i>	Five-year standard deviation of the terms of trade, capturing the variability in the terms of trade
<i>stdopen</i>	Five-year standard deviation of openness

In addition, according to (Ghosh, Phillips, 1998), the semi-log transformation helps to avoid that regression results are distorted by a few extreme inflation observations.

$$\tilde{\pi} = \begin{cases} \pi_{it} - 1, & \text{if } \pi_{it} \leq 1, \\ \ln(\pi_{it}), & \text{if } \pi_{it} > 1. \end{cases} \quad (3)$$

Annual data for the variables used were collected from different sources; growth rate of real GDP per capita, growth rate of population, real GDP per capita, exports and imports are from the UNCTAD online database, investment share of GDP is from Penn World Tables and inflation rates are from International Monetary Fund (IMF), online database.

4. Empirical results and discussion

The estimation results are presented in Tables 2, 3, 4, 5 and 6 respectively for CEMAC, COMESA, SADC, WAEMU and WAMZ. All estimation results are from Matlab software, version 2011b, using a MATLAB code written by Kremer, Bick and Nautz (2013)⁸. The results presented give the estimated threshold value, the confidence interval of the estimated threshold, as well as the impact of inflation below and above the estimated threshold, and the impact of the control variables included in the regression which are regime-independent. The estimation results for CEMAC in Table 2 suggest that the estimated threshold inflation for CEMAC is 1.38% and the 95% confidence interval is [0.46, 1.61], which does not contain the 3% inflation rate set as a convergence criterion by the members countries.

⁸ Much appreciation to Kremer, Bick and Nautz for making their Matlab code for dynamic panel threshold regression available.

Table 2. Inflation threshold effect on economic growth for CEMAC

<i>Estimated inflation threshold</i>		
γ	1.38%	
95% confidence interval	[0.46, 1.61]	
<i>Impact of regime-dependent regressors</i>		
Inflation	Estimated coefficients	Standard errors
β_1	0.340	0.904
β_2	−1.146**	0.485
<i>Impact of regime-independent regressors</i>		
	Estimated coefficients	Standard errors
$initial_{it}$	−18.384**	8.003
$popgr_{it}$	−0.111	0.548
inv_{it}	0.629**	0.162
tot_{it}	−0.119	0.08
$stdtot_{it}$	15.431	10.396
$open_{it}$	−1.240	4.079
$stdopen_{it}$	−20.657	15.894
δ_1	−4.748*	2.509

Notes: *, ** indicate significance at 10 and 5% respectively. Number of observations in the low-inflation regime is 29, and 19 in the high-inflation regime.

The findings indicate that in CEMAC an inflation rate of more than 1.61% is already high. The results further suggest that with an inflation rate below 1.38%, the effect on growth is positive $\hat{\beta}_1 = 0.340$ but statistically not significant and when inflation is above 1.38%, the impact of inflation on long-run growth is negative and statistically significant at 5%. The coefficient of inflation for high inflation regime is $\hat{\beta}_2 = -1.146$, indicating that a 1% increase of inflation above the inflation threshold leads to a decrease in long-run growth by 1.146%. The coefficients of the control variables (regime-independent variables) for CEMAC show that the variables such as initial income and investment ratio affect long-run growth at 5% level and their sign coefficients are as expected. The regime intercept is also statistically significant at 10% level.

For COMESA, the results presented in Table 3 indicate that the estimated threshold inflation is 13.13% with a 95% confidence interval of [3.07, 13.23] and contains the 5% inflation target set as a convergence criteria set by country members. In both regimes (below and above the threshold inflation), the impact of inflation on long-run growth is negative but only statistically significant (at 5% level) when inflation is above 13.13%. The coefficient of inflation for high inflation regime is $\hat{\beta}_2 = -3.389$, indicating that a 1% increase of inflation above the inflation threshold leads to a decrease in long-run growth by 3.389%.

Among the control variables included in the equation, only the coefficient of the standard deviation of terms of trade (capturing the variability of terms of trade) is statistically significant at 5% and bears the expected sign (negative), indicating that the variability of the terms of trade negatively affects long-run growth in COMESA. The regime intercept is also statistically significant at 5%.

Table 3. Inflation threshold effect on economic growth for COMESA

<i>Estimated inflation threshold</i>		
γ	13.13%	
95% confidence interval	[3.07, 13.23]	
<i>Impact of regime-dependent regressors</i>		
Inflation	Estimated coefficients	Standard errors
β_1	-0.287	0.268
β_2	-3.389**	1.430
<i>Impact of regime-independent regressors</i>		
	Estimated coefficients	Standard errors
$initial_{it}$	5.592	4.903
$popgr_{it}$	0.061	0.384
inv_{it}	0.0061	0.057
tot_{it}	-0.013	0.066
$stdtot_{it}$	-4.948**	2.099
$open_{it}$	0.560	0.906
$stdopen_{it}$	8.310	5.973
δ_1	-10.689**	4.667

Notes: ** indicates significance at 5% level. Number of observations in the low-inflation regime is 80, and 34 in the high-inflation regime.

As far as SADC is concerned, the estimation results in Table 4 suggest an inflation threshold of 12.77% which is close to that estimated for COMESA, with a 95% confidence interval of [7.72, 13.40]. The impact of inflation in both inflation regimes (below and above the inflation threshold) is negative but only statistically significant (at 5% level) in the high-inflation regime (above the threshold).

The coefficient of inflation for high inflation regime is $\hat{\beta}_2 = -3.702$ and statistically significant at 1%, indicating that a 1% increase of inflation above the inflation threshold leads to a decrease in long-run growth by 3.702%. The coefficient of openness to trade, among the regime-independent regressors included in the equation, is the only statistically significant variable at 5% and bears the expected sign (positive), indicating that openness to trade positively affects economic growth in SADC. The regime intercept is also statistically significant at 1%.

The results for WAEMU presented in Table 5 suggest that the estimated inflation threshold is 1.03% with a 95% confidence interval of [0.81, 2.79] and that the impact of inflation on the long-run growth in both regimes is negative but not statistically significant.

The coefficients of the control variables (regime-independent variables) for WAEMU indicate that the variables such as initial income, population growth, investment ratio, standard deviation of terms of trade, openness to trade and the standard deviation of openness (international trade) affect long-run growth at 5% level. However, the coefficients of initial income and investment ratio do not bear the expected signs. Otherwise, the results show that population growth, the variability of terms of trade and the variability of international trade negatively affect economic growth in WAEMU while openness to trade positively affects economic growth in that grouping.

Table 4. Inflation threshold effect on economic growth for SADC

Estimated inflation threshold		
γ	12.77%	
95% confidence interval	[7.72, 13.40]	
Impact of regime-dependent regressors		
Inflation	Estimated coefficients	Standard errors
β_1	-0.260	0.547
β_2	-3.702***	0.559
Impact of regime-independent regressors		
	Estimated coefficients	Standard errors
$initial_{it}$	-0.833	1.649
$popgr_{it}$	-0.131	0.565
inv_{it}	0.001	0.025
tot_{it}	0.008	0.027
$stdtot_{it}$	-0.043	1.123
$open_{it}$	3.360***	0.912
$stdopen_{it}$	2.977	3.161
δ_1	-10.013***	1.970

Notes: *** indicates significance at 1%. Number of observations in the low-inflation regime is 56, and 33 in the high-inflation regime.

Table 5. Inflation threshold effect on economic growth for WAEMU

<i>Estimated inflation threshold</i>		
γ	1.03%	
95% confidence interval	[0.81, 2.79]	
<i>Impact of regime-dependent regressors</i>		
<i>Inflation</i>	Estimated coefficients	Standard errors
β_1	-0.723	1.057
β_2	-0.019	0.977
<i>Impact of regime-independent regressors</i>		
	Estimated coefficients	Standard errors
$initial_{it}$	74.624***	19.980
$popgr_{it}$	-9.135***	2.569
inv_{it}	-0.971**	0.271
tot_{it}	-0.042	0.038
$stdtot_{it}$	-32.146***	6.566
$open_{it}$	10.242**	3.697
$stdopen_{it}$	-21.805***	5.577
δ_1	-1.997	1.711

Notes: **, *** indicate significance at 5 and 1% respectively. Number of observations in the low-inflation regime is 14, and 46 in the high-inflation regime.

Concerning WAMZ, the estimation results in Table 6 suggest a threshold level of inflation of 8.15% with a 95% confidence interval of [5.57, 12.80]. The impact of inflation on economic growth is as expected in both inflation regimes; positive impact for inflation below the threshold (8.15%) and negative impact for inflation above the threshold (8.15%), the results however indicate that the impact of inflation is statistically insignificant in both inflation regimes, at 5% level of significance.

The results on the impact of the control variables included in the regression for WAMZ indicate that initial income, population growth, openness to trade and the standard deviation of openness (international trade) affect long-run growth at 5% level. However, the signs on the coefficients of initial income and the standard deviation of openness (international trade) are not as expected. Otherwise, the results indicate that population growth and openness to trade affect positively economic growth in WAMZ.

Table 6. Inflation threshold effect on economic growth for WAMZ

Estimated inflation threshold		
γ	8.15%	
95% confidence interval	[5.57, 12.80]	
Impact of regime-dependent regressors		
Inflation	Estimated coefficients	Standard errors
β_1	1.00	1.627
β_2	-0.017	2.561
Impact of regime-independent regressors		
	Estimated coefficients	Standard errors
$initial_{it}$	12.774*	7.894
$popgr_{it}$	-3.794**	1.141
inv_{it}	-0.207	0.180
tot_{it}	0.075	0.073
$stdtot_{it}$	-4.008	6.098
$open_{it}$	5.724**	1.627
$stdopen_{it}$	26.400*	14.511
δ_1	3.277	7.466

Notes: *, ** indicate significance at 10 and 5% respectively. Number of observations in the low-inflation regime is 14, and 31 in the high-inflation regime.

5. Comparison with other studies

It should be noted that the values of the inflation threshold estimated in this study for African regional economic communities are somewhat different from those of some previous studies on developing countries. Khan and Senhadji (2001) found an inflation threshold of 11% for developing countries; Seleteng et al. (2013) using panel smooth threshold regression (PSTR) found an inflation threshold of 18.9% for SADC; Ibarra and Trupkin (2011) using panel smooth thresh-

old regression (PSTR) on a sample of non-industrialized countries found an inflation threshold of 19.1%; Bick (2010) using non-dynamic panel threshold regression of Hansen (1999) on a sample of 40 developing countries found an inflation threshold of 19.16%, and Kremer et al. (2013) using dynamic panel threshold regression found an inflation threshold of 17.2% for a sample of developing countries.

However, the difference in the findings is not surprising; as Kremer et al. (2013) warn, «avoiding the endogeneity bias in a panel threshold model may lead to very different conclusions». Kremer et al. (2013) point also out that ignoring the endogeneity problem «can lead to biased estimates of inflation threshold and to misleading conclusions about the impact of inflation on growth in the corresponding inflation regimes». Indeed, Khan and Senhadji (2001), Bick (2010), Ibarra and Trupkin (2011), and Seleteng et al. (2013), all include initial income among the control variables in the growth equation, but use methodologies (i. e. non-dynamic panel threshold regression and non-dynamic panel smooth threshold regression) which do not account for the endogeneity problem it creates.

In addition, these studies (Khan, Senhadji, 2001; Bick, 2010; Ibarra, Trupkin, 2011; Seleteng et al., 2013; Kremer et al., 2013) pit together countries from Africa, Asia and Latin America which have different levels of economic development, different macroeconomic policies as well as different inflation experiences. In fact, Bick (2010), Ibarra and Trupkin (2011), and Kremer et al. (2013) all use a sample of 101 developing countries including only 40 African countries.

Furthermore, as Seleteng et al. (2013) point out, the level of inflation threshold varies from country to country depending on the stage of economic development, institutional arrangements and structural realities, as well as macroeconomic policies applied. They add that the choice of estimation model plays an important role in examining nonlinearities in the inflation-growth nexus.

However, our findings for COMESA and SADC corroborate those of Seleteng et al. (2013), Ibarra and Trupkin (2011) and Kremer et al. (2013) who also found that the impact of inflation on long-run growth is negative all across the inflation regimes (below and above the inflation threshold) but only statistically significant for the segment of inflation above the threshold. Khan and Senhadji (2001) also found that the impact of inflation on growth is only statistically significant above the threshold.

6. Concluding remarks

This study entails estimating inflation threshold and examining its impact on inflation-growth nexus in CEMAC, COMESA, SADC, WAEMU and WAMZ. Dynamic Panel Threshold modeling was used and the findings suggest that the estimated inflation threshold is 1.38% for CEMAC, 13.13% for COMESA, 12.77% for SADC, 1.03% for WAEMU and 8.15% for WAMZ. It should be noted that for WAEMU and WAMZ, the impact of inflation on growth was found to be insignificant in all the inflation regimes, above and below the threshold. This questions the non-linearity hypothesis of the relationship between inflation and growth in those two economic communities.

In addition, the results indicate that the estimated inflation threshold for COMESA and SADC is above the inflation target set for convergence [COMESA (5%), SADC (3%)], while for CEMAC, the estimated inflation threshold is below the inflation target set for convergence

[CEMAC (3%)]. Moreover, for CEMAC, COMESA and SADC, the findings show that inflation above the threshold is harmful to growth. Furthermore, the results indicate that the estimated inflation threshold is different across regional economic groupings, which is not surprising given that the inflation experiences and monetary policies in those communities are also different. For CEMAC and WAEMU, the estimated inflation threshold is quite low (around 1%) as compared to other communities. This is because the level of inflation in CEMAC and WAEMU is also low, probably due to their membership in the CFA franc zone with fixed parity between the Euro and the CFA franc.

References

- Altig D. E. (2003). What is the right inflation rate? *Federal Reserve Bank of Cleveland, Economic Commentary*, 09.15.2003.
- Arellano M., Bover O. (1995). Another look at the instrumental variables estimation of error components models. *Journal of Econometrics*, 68 (1), 29–51.
- Bick A. (2010). Threshold effects of inflation on economic growth in developing countries. *Economics Letters*, 108 (2), 126–129.
- Caner M., Hansen B. E. (2004). Instrumental variable estimation of a threshold model. *Econometric Theory*, 20 (5), 813–843.
- Choi S., Smith B. D., Boyd J. H. (1996). Inflation, financial markets and capital formation. *Federal Reserve Bank of St. Louis Review*, 78 (3), 9–35.
- Drukker D., Gomis-Porqueras P., Hernandez-Erme P. (2005). Threshold effects in the relationship between inflation and growth: A new panel data approach. *MPRA Paper No. 38225*.
- Fischer S. (1983). Inflation and growth. *NBER Working paper No. 1235*.
- Fischer S. (1993). The role of macroeconomic factors in growth. *NBER Working Paper No. 4565*.
- Fischer S., Modigliani F. (1978). Towards an understanding of the real effects and costs of inflation. *Weltwirtschaftliches Archiv*, 114 (4), 810–833.
- Friedman M. (1977). Nobel lecture: Inflation and unemployment. *Journal of Political Economy*, 85 (3), 451–472.
- Ghosh A., Phillips S. (1998). Warning: Inflation may be harmful to your growth. *IMF Staff Papers*, 45 (4), 672–686.
- Gonzalez A., Terasvirta T., van Dijk D. (2005). Panel smooth transition regression models. *SSE/EFI Working Paper Series in Economics and Finance*, No. 604.
- Hansen B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. *Journal of Econometrics*, 93 (2), 345–368.
- Ibarra R., Trupkin D. (2011). The relationship between inflation and growth: A panel smooth transition regression approach. *Documentos de Trabajo/Working Papers 1107, Facultad de Ciencias Empresariales y Economia. Universidad de Montevideo*.
- International Monetary Fund (2005). Gabon: First review under the stand-by arrangement-staff report. *IMF Country Report No. 05/3*.
- International Monetary Fund (2009). Republic of Congo: Staff report for the 2013 Article IV consultation. *IMF Country Report No. 09/74*.

International Monetary Fund (2013). Republic of Congo: Staff report for the 2013 Article IV consultation. *IMF Country Report* No. 13/282.

Khan M. S., Senhadji A. S. (2001). Threshold effects in the relationship between inflation and growth. *IMF Staff Papers*, 48 (1), 1–21.

Kremer S., Bick A., Nautz D. (2013). Inflation and growth: New evidence from a dynamic panel threshold analysis, *Empirical Economics*, 44 (2), 861–878.

Mundell R. A. (1965). Growth, stability and inflationary finance. *The Journal of Political Economy*, 73 (2), 97–109.

Sarel M. (1996). Nonlinear effects of inflation on economic growth. *IMF paper series*, 43 (1), 199–215.

Seleteng M., Bittencourt M., van Eyden R. (2013). Nonlinearities in inflation-growth nexus in the SADC region: Panel smooth transition regression approach. *Economic Modelling*, 30, 149–156.

Stockman A. C. (1981). Anticipated inflation and the capital stock in a cash-in-advance economy. *Journal of Monetary Economics*, 8, 387–393.

Thanh S. D. (2015). Threshold effects of inflation on growth in the ASEAN-5 countries: A panel smooth transition regression approach. *Journal of Economics, Finance and Administrative Science*, 20, 41–48.

Tobin J. (1965). Money and economic growth. *Econometrica*, 33, 671–684.

Received 03.06.2015; accepted 13.02.2016.

APPENDIX

Table A1. Description of African regional economic communities

CEMAC	Communauté Economique et Monétaire de l'Afrique Centrale (Economic and Monetary Community of Central Africa)
COMESA	Common Market for Eastern and Southern Africa
EAC	East African Community
SADC	Southern African Development Community
WAEMU	West African Economic and Monetary Union
WAMZ	West African Monetary Zone

Table A2. Inflation Experience in African regional economic communities (% averages)

	CEMAC	COMESA*	SADC**	WAEMU	WAMZ
1985–1989	0.3	20.7	20.5	8.4	20.9
1990–1999	4.9	29.6	78.4	8.3	13.6
2000–2011	3.1	10.4	13.5	2.7	12.1
1985–2011	3.3	19.6	41.8	5.3	13.8

Notes: Table constructed using CPI data from International Financial Statistics, IMF, online database.

* — COMESA excludes Comoros, Eritrea and Zimbabwe. ** — SADC excludes Zimbabwe.

Table A3. Sample of African countries used and date range before five-year averaging

Region/Country	Sample period	Number of observations	Region/Country	Sample period	Number of observations
CEMAC			Mauritius	1970–2011	41
Central African Rep.	1980–2011	31	Mozambique	1990–2011	21
Cameroon	1970–2011	41	Namibia	1990–2011	21
Chad	1985–2011	26	Seychelles	1970–2011	41
Congo Republic	1985–2011	26	South Africa	1970–2011	41
Equatorial Guinea	1985–2011	26	Swaziland	1980–2011	31
Gabon	1970–2011	41	Tanzania	1970–2011	41
COMESA*			Zambia	1985–2011	26
Burundi	1970–2011	41	WAEMU		
Congo, D. Republic	1970–2011	41	Benin	1990–2011	21
Djibouti	1980–2011	31	Burkina Faso	1960–2011	51
Egypt	1970–2011	41	Guinea Bissau	1985–2011	26
Ethiopia	1970–2011	41	Ivory Cost	1960–2011	51
Kenya	1970–2011	41	Mali	1990–2011	21
Libya	1985–2011	26	Niger	1965–2011	46
Madagascar	1970–2011	41	Senegal	1965–2011	46
Malawi	1980–2011	31	Togo	1965–2011	46
Mauritius	1970–2011	41	WAMZ		
Rwanda	1970–2011	41	Gambia	1965–2011	46
Seychelles	1970–2011	41	Ghana	1965–2011	46
Sudan	1970–2011	41	Guinea	1985–2011	26
Swaziland	1980–2011	31	Liberia	1975–2011	36
Uganda	1980–2011	31	Nigeria	1960–2011	51
Zambia	1985–2011	26	Sierra Leone	1985–2011	26
SADC**					
Angola	1990–2011	21			
Botswana	1980–2011	31			
Congo, D. Republic	1985–2011	26			
Lesotho	1980–2011	31			
Madagascar	1970–2011	41			
Malawi	1980–2011	31			

Notes: * — Comoros, Eritrea were excluded because of data unavailability, and Zimbabwe was excluded because of its recent hyperinflation, the estimation of the inflation threshold could be biased by that.

** — For SADC, Zimbabwe was excluded because of the same reason as stated above.

Table A4. Time dimension with five-year averages

Region/Country	<i>T</i>	Mean inflation	Mean growth	Region/Country	<i>T</i>	Mean inflation	Mean growth
CEMAC				Mauritius	8	8.17	4.11
Central African Rep.	6	3.23	-1.18	Mozambique	4	18.44	2.50
Cameroon	8	6.25	0.67	Namibia	4	8.46	1.54
Chad	5	3.26	2.36	Seychelles	8	6.87	2.88
Congo Republic	5	4.16	-0.33	South Africa	8	9.29	0.59
Equatorial Guinea	5	3.99	12.25	Swaziland	6	9.86	2.68
Gabon	8	5.12	1.11	Tanzania	8	15.57	1.37
COMESA				Zambia	5	34.50	-0.09
Burundi	8	9.96	0.28	WAEMU			
Congo, D. Republic	8	85.25	-2.98	Benin	4	1.11	1.05
Djibouti	6	4.32	-1.07	Burkina Faso	10	0.29	1.56
Egypt	8	10.10	3.08	Guinea Bissau	5	13.28	-0.27
Ethiopia	8	8.21	1.21	Ivory Cost	10	1.23	-0.04
Kenya	8	11.60	0.98	Mali	4	-0.12	2.28
Libya	5	3.31	-1.85	Niger	9	-0.002	-1.40
Madagascar	8	12.21	-1.13	Senegal	9	0.70	-0.16
Malawi	6	17.52	0.20	Togo	9	0.68	0.22
Mauritius	8	8.17	4.11	WAMZ			
Rwanda	8	9.63	1.84	Gambia	9	8.11	0.68
Seychelles	8	6.87	2.88	Ghana	9	24.10	0.51
Sudan	8	27.17	2.04	Guinea	5	1.69	0.67
Swaziland	6	9.86	2.68	Liberia	7	8.56	-2.65
Uganda	6	25.12	2.44	Nigeria	10	14.55	1.43
Zambia	5	34.50	-0.09	Sierra Leone	5	13.66	0.04
SADC							
Angola	4	313.44	2.99				
Botswana	6	9.48	4.72				
Congo, D. Republic	8	85.25	-2.98				
Lesotho	6	9.83	1.88				
Madagascar	8	12.21	-1.13				
Malawi	6	17.52	0.20				

Source: Own computations using data from UNCTAD and IMF.

Table A5. Average level of real GDP per capita (1980–2011) (US Dollar at 2005 prices)

Region/Country	GDP per capita	Region/Country	GDP per capita
CEMAC	2776.7	Mauritius	3918.7
Central African Republic	405.3	Mozambique	235.0
Cameroon	989.8	Namibia	3169.2
Chad	408.6	Seychelles	9980.9
Congo Republic	1777.4	South Africa	4864.4
Equatorial Guinea	5324.0	Swaziland	2005.7
Gabon	7755.3	Tanzania	311.7
COMESA	1817.2	Zambia	675.8
Burundi	181.9	WAEMU	509.7
Congo, D. Republic	208.7	Benin	520.6
Djibouti	1094.0	Burkina Faso	315.6
Egypt	1028.1	Guinea Bissau	452.8
Ethiopia	157.5	Ivory Cost	981.3
Kenya	527.1	Mali	349.3
Libya	7511.9	Niger	285.2
Madagascar	308.1	Senegal	730.5
Malawi	222.8	Togo	442.4
Mauritius	3918.7	WAMZ	445.6
Rwanda	264.1	Gambia	416.7
Seychelles	9980.9	Ghana	683.0
Sudan	714.7	Guinea	296.0
Swaziland	2005.7	Liberia	297.0
Uganda	275.5	Nigeria	636.0
Zambia	675.8	Sierra Leone	345.1
SADC	2281.4		
Angola	1694.2		
Botswana	3790.2		
Congo, D. Republic	208.7		
Lesotho	554.5		
Madagascar	308.1		
Malawi	222.8		

Notes: COMESA excludes Comoros, Eritrea and Zimbabwe. SADC excludes Zimbabwe.

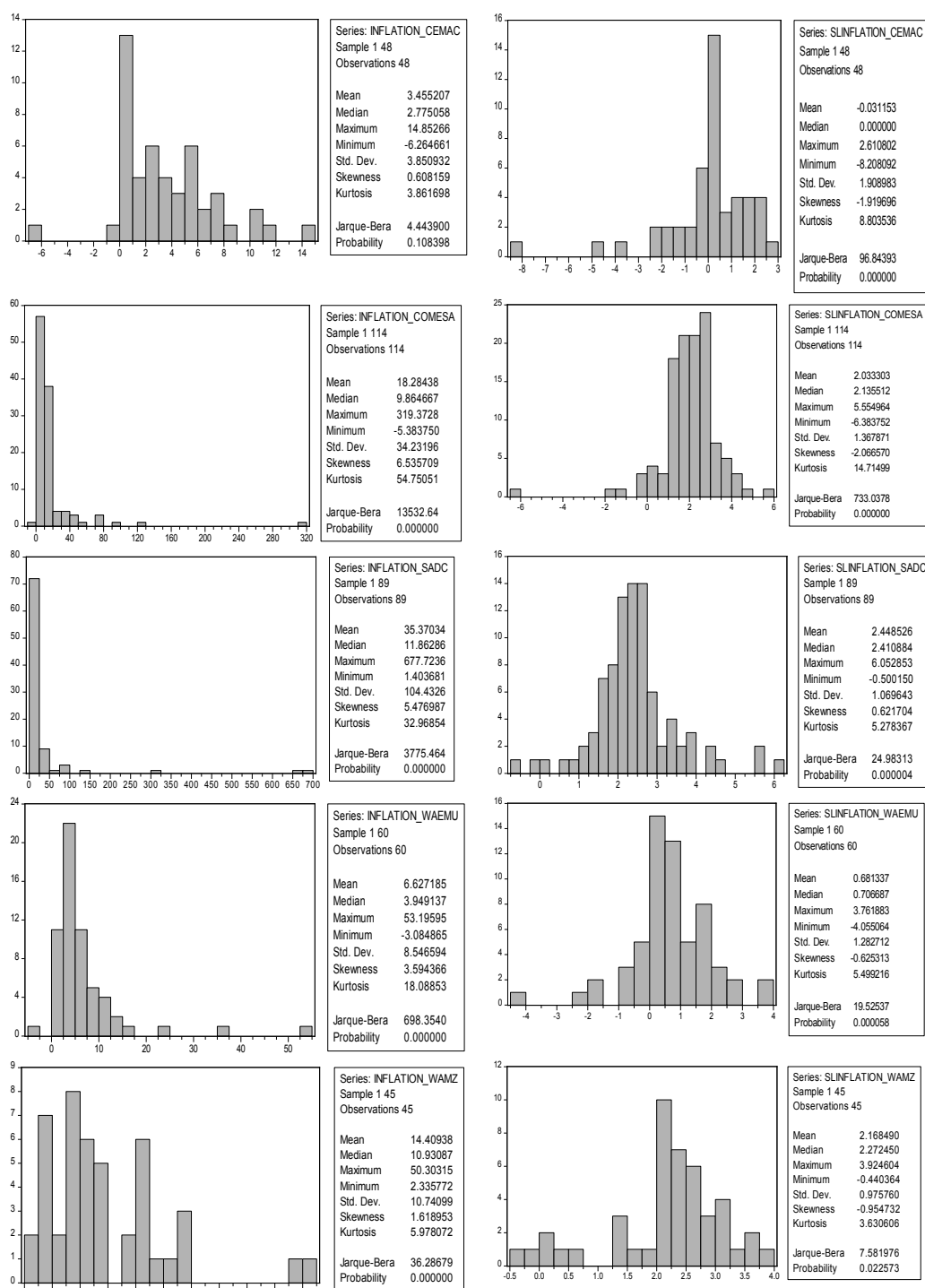


Fig. 1. Five-year average of annual inflation before and after semi-log transformation (INFLATION stands for inflation before semi-log transformation and SLINFLATION stands for semi-log transformed inflation)

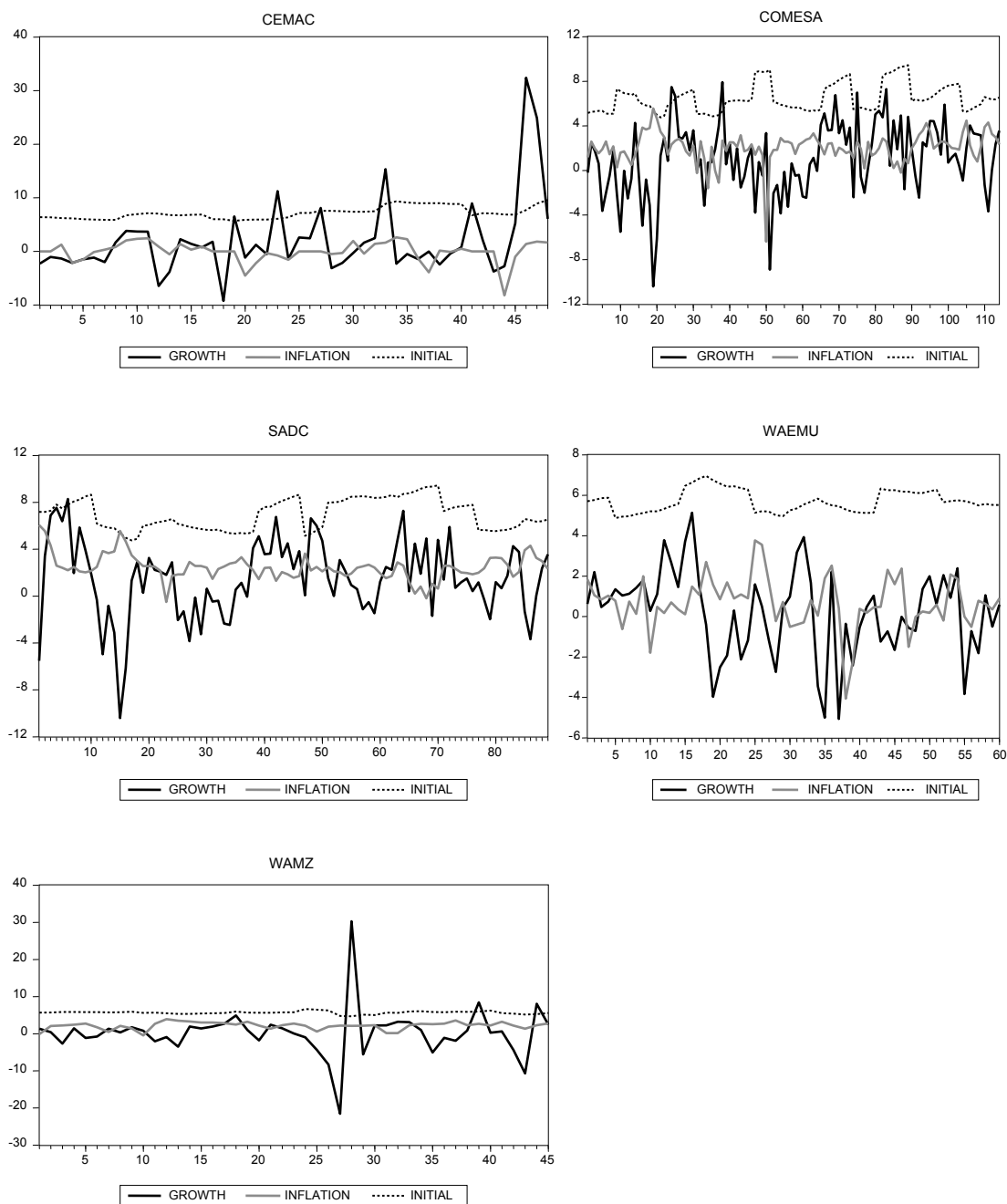


Fig. 2. Inflation, growth and initial income in selected regional economic communities (figures are constructed using data from UNCTAD and IMF
INITIAL stands for initial income)