

ASSESSMENT OF THE FISCAL SUSTAINABILITY IN AFRICA USING THE PANEL UNIT ROOT AND COINTEGRATION TESTS

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One of the approaches to examine fiscal sustainability is to test the intertemporal budget constraint, which involves testing the stationarity of government revenues and expenditures, the primary budget balance, and the first differences of public debt. Part of this approach includes testing cointegration and causality among different pairs of variables. This paper focuses on assessing the fiscal sustainability of African group of countries in the period between 1995 and 2021. It has been found that fiscal sustainability is present, but in a weak form. Fiscal sustainability was confirmed when considering a constant and trend in calculations, while deviations were observed among first- and second-generation unit roots tests, and considered different pairs of fiscal variables. The study serves as a starting point for a more extensive analysis of fiscal sustainability. For more accurate findings, it would be necessary to categorize countries into smaller and economically more homogeneous groups and analyze them using other fiscal sustainability methods as well.

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1 Introduction

Recurring periods of increasing public debt and its persistence at relatively high levels raise concerns about the fiscal sustainability of countries. When examining the issue of fiscal sustainability, both the negative effects of public borrowing and the causes leading to unbalanced public finances are identified (Brady & Magazzino, 2018). Fiscal sustainability is focused on two key public finance variables, namely the primary budget balance and public debt. The definition of fiscal sustainability, which represents the equalization of the present value of future budget surpluses with the current level of public debt, can be derived in the context of the intertemporal budget constraint. When the conditions of the intertemporal budget constraint are met, the government has the ability to manage its public debt, since the debt rollover does not cause excessive accumulation and does not pose a risk of insolvency (Krejdl, 2006). If a country meets the conditions of fiscal sustainability, it can reflect favorable conditions for investing in its government bonds, since there is a relatively small probability of sovereign risk or state bankruptcy (Chen, 2014).

The definition of fiscal sustainability outlines the government's ability to maintain credible public finances and the ability to provide public services in the long term. Ensuring long-term fiscal sustainability and appropriate budget planning requires strategic monitoring and forecasting of future revenues and liabilities, environmental factors, and other socio-economic trends (OECD, 2013).

In this study, we examined the fiscal sustainability of African group of countries. We first reviewed the theory and empirical evidence that allowed us to determine the appropriate methodological approach and select the data set. In the results chapter, we first presented descriptive statistics, then proceeded to present the first generation unit root tests and Pesaran's second-generation unit root test. After verifying the stationarity of the fiscal variables in question, we conducted cointegration testing on various pairs of variables using Pedroni's test.

2 Theoretical background / literature review

The theoretical basis for studying the fiscal sustainability of countries is provided by the arithmetic of the budget balance, which demonstrates the connections between key fiscal variables. The budget deficit represents a negative balance of the budget

and affects the accumulation of public debt, as budget deficits are financed through the issuance of government bonds, and the sum of budget deficits over time represents the accumulated public debt (Case et al., 2012, p. 179). In studying fiscal sustainability, focus is often placed on the primary budget balance and public debt, which define the fiscal conditions in a country (Croce & Juan-Ramón, 2003). If the primary budget balance is in deficit, or if the surplus of the primary budget balance is smaller than the real interest repayments on public debt, the country will find itself in a budget deficit. The reasons for a deficit in the primary budget balance can vary. The most common reasons are the need for countercyclical fiscal policy, wars and natural disasters, structural reforms of the economy, delays in public financial consolidation, external shocks, and various economic-psychological factors (Guellec & Wunsch-Vincent, 2009; Döring & Oehmke, 2019).

Chen (2014) analyzed the fiscal sustainability of the G7 group of countries and selected European countries using quarterly data from the first quarter of 1980 to the fourth quarter of 2012. By testing for the presence of a unit root in the public debt-to-GDP ratio variable, the author found that a unit root is present in the sample under study, indicating a violation of the solvency condition. The public debt-to-GDP ratio shows time series stationarity for Canada, Germany, the USA, and Italy when calculations take into account a nonlinear trend in the long term and asymmetric data adjustment. Brady and Magazzino (2019) investigated the stationarity and cointegration of budget revenues and expenditures in the case of Italy, examining the long-term characteristics of both fiscal variables between 1862 and 2013. It was found that a unit root is present throughout the entire period, which rejects the condition of fiscal sustainability, although weak cointegration can be detected, suggesting the weak presence of fiscal sustainability. The authors divided the entire observed period into different sub-periods and found that fiscal sustainability can be confirmed for the sub-period between 1862 and 1913, while fiscal sustainability cannot be confirmed for the period 1947-2013.

Nzimande and Ngalava (2019) studied a group of 13 countries of the Southern African Development Community for the period 1980-2014, testing for the presence of a unit root with Pesaran's test and cointegration with Westerlund's test on the variables of budget expenditures and revenues. The authors did not reject the null hypothesis of the presence of a unit root, as the variables of budget expenditures and revenues are integrated of order one. Nevertheless, cointegration between the

two fiscal variables could be confirmed, hence Nzimande and Ngalava (2019) confirmed the presence of fiscal sustainability in the countries under study.

In their study of 19 European Union countries between 1996 and 2020, Afonso and Coelho (2022) also confirmed the solvency condition, as the first difference of the stock of real public debt showed stationarity using Pesaran's unit root test. Long-term cointegration links between budget revenues and expenditures, the primary budget balance as a percentage of GDP, public debt as a percentage of GDP, and public debt as a percentage of GDP with the primary budget balance as a percentage of GDP lagged by one time unit were also confirmed. The authors confirmed fiscal sustainability of the countries under study with the fiscal reaction function test. They also found that fiscal rules and the overall budget as a percentage of GDP positively influence fiscal sustainability, while trade openness as a percentage of GDP, the current account balance as a percentage of GDP, and government efficiency negatively affect the primary budget balance.

3 Methodology and description of the dataset

The field of research on the fiscal sustainability of countries is related to the solvency of the public budget, which refers to meeting the intertemporal budget constraint. The fundamental variables studied in fiscal sustainability are public debt and primary budget balance (Bohn, 2007). The empirical literature distinguishes two standard approaches for verifying the solvency of the public budget. The first approach focuses on examining the characteristics of time series of fiscal and macroeconomic variables. This approach involves testing the stationarity and cointegration of various fiscal variables. However, this verification does not allow for firm conclusions about fiscal sustainability due to assumptions about the characteristics of fiscal variable time series. Therefore, a second approach emerged in the empirical literature, established by Bohn (1998; 2005; 2007) for testing the solvency of the public budget by estimating the fiscal reaction function. Bohn's method of testing fiscal sustainability involves estimating the marginal responsiveness of the budget surplus to various fiscal, macroeconomic, and other variables. With this approach, fiscal sustainability can be confirmed based on the positive marginal responsiveness of the budget balance to changes in public debt and other studied variables (Cho & Lee, 2022).

In this research, we will limit ourselves to the approach of testing the stationarity and cointegration of various fiscal variables. This approach follows the intertemporal budget constraint, which condition is met, when government revenues and expenditures are integrated of order zero. This state would indicate the presence of fiscal sustainability. Different orders of integration between government revenues and expenditures would indicate that there is no fiscal sustainability in the covered group of countries. If the both main studied fiscal variables are integrated of order one it is necessary to test the cointegration between government revenues and expenditures (Afonso, 2005). The approach of assessing the fiscal sustainability with panel unit root tests and cointegration has the important limitation only indicates the presence of fiscal sustainability and does not identify the factors of fiscal sustainability (Can, 2023).

In line with the research of Afonso and Coelho (2022) and other studies presented in the literature review, data were collected for budget revenues, budget expenditures, the primary budget balance, and public debt. All the variables under study are expressed as a percentage of GDP. Annual data has been retrieved from the IMF database (2023), designed by Mauro et al. (2015). The selection of African countries was based on the availability of data for the period between 1995 and 2021, which represents our study period. We have investigated the fiscal sustainability in a group of 32 African countries¹, which represents 864 observations. All estimates were conducted in econometrical program EViews 13.

4 Results

In this chapter, we first present results of the first-generation unit root tests of Levin, Lin & Chu (LLC), and Im, Pesaran & Shin (IPS), which we used to test the stationarity of budget revenues and expenditures, the primary budget balance, and the first difference of public debt. We then checked for the presence of a unit root on the same variables using Pesaran's test, as this second-generation unit root test accounts for cross-sectional dependence. Conclusions about the presence of fiscal

¹ Covered African countries in the study were: Algeria, Benin, Burkina Faso, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Congo, Djibouti, Equatorial Guinea, Eswatini, Ethiopia, Gabon, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Morocco, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, South Africa, Sudan, Tanzania, Togo, and Tunisia.

sustainability in the group of countries under study were made after conducting Pedroni's cointegration test.

4.1 Panel Unit Root Tests

First-generation unit root tests that account for cross-sectional independence are the first step in verifying fiscal sustainability. The rejection of a unit root in the first difference of public debt would verify the solvency condition. The selected first-generation panel unit root tests are Levin, Lin & Chu test and Im, Pesaran & Shin test, which both assumes the heterogeneity and cross-sectional independence. The main difference between tests is assumption in the unit root process, as LLC test assumes a common unit root process, while IPS tests assumes an individual unit root process. The calculations included automatic lag selection based on the Schwarz Information Criterion, and spectral estimation was based on the Newey-West selection of bandwidth using Bartlett's kernel, assuming asymptotically normal distribution. Under the null hypothesis of both tests we would test the presence of unit root (Afonso & Rault, 2010).

Table 1: Estimates of the Levin, Lin & Chu and Im, Pesaran & Shin panel unit root tests

	Levin, Lin & Chu panel unit root test		Im, Pesaran & Shin panel unit root test	
	Statistic	p-value	Statistic	p-value
<i>Constant</i>				
Government revenue (% of GDP)	-4.02057	0.0000	-2.25532	0.0121
Government expenditure (% of GDP)	-3.21325	0.0000	-2.53763	0.0056
Primary budget balance (% of GDP)	-9.35805	0.0000	-6.48067	0.0000
First Difference of the Public debt (% of GDP)	-16.3197	0.0000	-16.2201	0.0000
<i>Constant and trend</i>				
Government revenue (% of GDP)	-4.47286	0.0000	-4.30719	0.0000
Government expenditure (% of GDP)	-5.46798	0.0000	-3.87034	0.0001
Primary budget balance (% of GDP)	-11.3642	0.0000	-6.21848	0.0000
First Difference of the Public debt (% of GDP)	-12.5220	0.0000	-13.8185	0.0000

Authors' calculation

In Table 2 are presented the estimates of LLC and IPS tests. All considered fiscal variables are integrated of order zero at 1% significance when looking at LLC test. Similarly, the presence of unit root is rejected with IPS test at 1% significance for all fiscal variables except government revenue, which are stationary with considered

constant at 5% significance. With both LLC and IPS tests the solvency condition is met, as the first difference of public debt is stationary.

Table 2: Estimates of the Pesaran’s second-generation panel unit root test

<i>Constant</i>	CIPS statistic	<i>Critical values of CIPS statistic</i>
Government revenue (% of GDP)	-2,07310*	1 % = -2,30
Government expenditure (% of GDP)	-2,01572	5 % = -2,15
Primary budget balance (% of GDP)	-2,73163***	10 % = -2,07
First Difference of the Public debt (% of GDP)	-3,72472***	
<i>Constant and trend</i>		
Government revenue (% of GDP)	-2,98306***	1 % = -2,81
Government expenditure (% of GDP)	-2,62638*	5 % = -2,66
Primary budget balance (% of GDP)	-3,18237***	10 % = -2,58
First Difference of the Public debt (% of GDP)	-4,05814***	

Authors' calculation

Notes: ***statistically significant at 1% significance level, ** statistically significant at 5% significance level.

However, the empirical literature points out the importance of taking into account the cross-dependence, therefore the second-generation panel unit root tests were considered (Afonso & Coelho, 2022). In line with characteristic, we have also assessed the fiscal sustainability using the Pesaran's second-generation unit root test that assumes the cross-dependence. In Table 3 are presented the estimates of the Pesaran’s panel unit root test, which lead us to different conclusions than both first-generation unit root tests. The first difference of public debt is statistically significantly stationary at less than 1% risk of rejecting the existence of a unit root process with both a constant and a constant and trend. For government revenues, the null hypothesis of a unit root process can be rejected at a 10% statistical significance level when considering a constant, while this variable is statistically significant at less than 1% with both a constant and trend. Government expenditures in African countries are stationary only at a 10% statistical significance level when considering both a constant and trend, which cannot be claimed when considering only a constant, as the null hypothesis of the presence of a unit root process cannot be rejected. On the other hand, the primary budget balance is stationary both with a constant and with a constant and trend. Pesaran's unit root test provided completely different results in assessing fiscal sustainability compared to first-generation unit root tests. Considering a constant in Pesaran's unit root test, it can be stated at a 5% significance level that African countries are fiscally unsustainable. However, considering both a constant and trend in the second-generation unit root test, at a

10% significance, we can accept the first-order integration for government expenditures and revenues. These findings also had to be verified with cointegration tests of fiscal variables.

4.2 Pedroni Cointegration Test

We have proceeded testing the fiscal sustainability with employing the Pedroni Cointegration Test. Following Afonso & Coelho (2022) approach, we have tested the cointegration of the following pairs of fiscal variables: government revenue and government expenditure, primary budget balance and lagged public debt, and public debt and lagged primary budget balance. In the calculations of the Pedroni test, spectral estimation was based on Newey-West bandwidth selection using the Bartlett kernel, while assuming one lag.

Table 3: Pedroni's cointegration test

Relation	Revenues and expenditures		Primary balance and lagged debt		Debt and lagged primary balance	
	No trend	Trend	No trend	Trend	No trend	Trend
Within-dimension						
Panel ν	10,5484***	4,9245***	4,1592***	-0,3197	5,3668***	0,5598
Panel ρ	-17,081***	-14,1906***	-7,1144***	-4,8442***	-13,461***	-11,2900***
Panel PP	-24,133***	-22,891***	-7,6486***	-8,0184***	-13,867***	-16,098***
Panel ADF	-4,1920***	-2,1541***	-3,8303***	-3,4768***	-4,4789***	-4,9332***
Between-dimension						
Group ρ	-5,0910***	-2,5941***	-4,8307***	-2,8620***	-5,9721***	-4,4017***
Group PP	-7,7680***	-7,3456***	-8,0491***	-8,9015***	-9,3700***	-13,4063***
Group ADF	-3,6312***	-3,7432***	-5,0920***	-6,3710***	-5,0074***	-7,1234***

Authors' calculation

Notes: ***statistically significant at 1% significance level, ** statistically significant at 5% significance level.

Using the Pesaran's unit root test, we found that government revenue is integrated of order zero at a 10% level of statistical significance, while we failed to reject the null hypothesis of a unit root process for government expenditure when constant is considered. Given these results of the unit root test at a 10% level of significance, further testing of fiscal sustainability with only taking constant into account is

precluded as the same order of integration was not confirmed. The Pedroni Cointegration Test for the group of African countries can only be continued at a lower level of statistical significance and considering only the estimates with constant and trend. In Table 4, displaying the results of the Pedroni Cointegration Test for African group of countries, we can infer that there is cointegration among all examined pairs of fiscal variables when the constant term is considered. Based on these estimates, fiscal sustainability can be confirmed in the studied group of African countries, but these estimates are not representative as there is different order of integration of considered fiscal variables. However, considering both the constant and trend, cointegration among the examined pairs of fiscal variables cannot be confirmed due to differing results of the test statistics, as all cases of the panel ν - statistics are statistically insignificant. Along with these estimates, we can conclude that there is are presence of weak fiscal sustainability, as there is, however, some indication of cointegration from other test statistics.

6 Conclusions

We examined fiscal sustainability in the African group of countries over the period 1995–2021. The panel data of African countries consisted of fiscal variables such as government revenue, government expenditure, primary budget balance, and public debt, with all analyzed variables expressed as a percentage of GDP. The methodology for examining fiscal sustainability followed the procedure of Afonso and Rault (2010) and Afonso and Coelho (2022). We have confirmed the solvency condition for the considered group of countries, as the first difference of public debt is estimated to be stationary with all three panel unit root tests that were considered. However, there was some discrepancy between first and second-generation unit root tests. IPS and LLC tests rejected the unit root in at least 5% significance for government revenues and expenditures, while both variables were integrated of the order zero. Oppositely, Pesaran's unit root test have only rejected the unit root process for both government revenues and government expenditures at 10% significance considering constant and trend. Therefore, further cointegration and casualty estimates were considered only for constant and trend when assessing the fiscal sustainability of African countries. Pedroni Cointegration Test estimates rejected the cointegration between considered pairs of fiscal variables considering constant and trend, as there were different conclusions from test statistics. These estimates lead to the conclusion that there is a weak fiscal sustainability for African

countries in the covered period. These estimates can not be compared with the studies covered in the literature review, as we have conducted a research on the wider group of countries. A reasonable extension of the research would be the estimation of the fiscal reaction function, which would enable to identify the determinants of fiscal sustainability. Furthermore, the further studies should be conducted on the smaller and more homogeneous group of countries. This research represents a starting point for the further analysis of the fiscal sustainability in different group of countries.

References

- Afonso, A. (2005). Fiscal sustainability: The unpleasant European case. *FinanzArchiv/Public Finance Analysis*, 61(1), 19-44. <http://dx.doi.org/10.1628/0015221053722532>
- Afonso, A., & Coelho, J. C. (2022). Fiscal Sustainability, Fiscal Reactions, Pitfalls and Determinants. *CESifo Working Paper No. 9635*. München: CESifo. <http://dx.doi.org/10.2139/ssrn.4063444>
- Afonso, A., & Rault, C. (2010). What Do We Really Know About Fiscal Sustainability in the EU? A Panel Data Diagnostic. *Review of World Economics*, 145, 731-755. <http://dx.doi.org/10.1007/s10290-009-0034-1>
- Bohn, H. (1998). The Behavior of US Public Debt and Deficits. *The Quarterly Journal of Economics*, 113(3), 949-963. <https://msuweb.montclair.edu/~lebelp/BohnPubDebtQJE1998.pdf>
- Bohn, H. (2005). The Sustainability of Fiscal Policy in the United States. *CESifo Working Paper No. 1446*. München: CESifo. <http://dx.doi.org/10.2139/ssrn.708173>
- Bohn, H. (2007). Are Stationarity and Cointegration Restrictions Really Necessary for the Intertemporal Budget Constraint? *Journal of Monetary Economics*, 54(7), 1837-1847. <http://dx.doi.org/10.1016/j.jmoneco.2006.12.012>
- Brady, G. L., & Magazzino, C. (2018). Fiscal Sustainability in the EU. *Atlantic Economic Journal*, 46, 297-311. <http://dx.doi.org/10.1007/s11293-018-9588-4>
- Brady, G. L., & Magazzino, C. (2019). Government Expenditures and Revenues in Italy in a Long-Run Perspective. *Journal of Quantitative Economics*, 17, 361-375. <http://dx.doi.org/10.1007/s40953-019-00157-z>
- Can, C. K. (2023). Estimating Bohn's Fiscal Sustainability Model with Temporal Variation: Evidence from Turkey. *Prague Economic Papers*, 32(1), 61-83 <http://dx.doi.org/10.18267/j.pep.822>
- Case, K. E., Fair, R. C., & Oster, S. M. (2012). *Principles of Macroeconomics* (10. iss.). Boston: Pearson.
- Chen, S. W. (2014). Testing for fiscal sustainability: New evidence from the G-7 and some European countries. *Economic Modelling*, 37, 1-15. <http://dx.doi.org/10.1016/j.econmod.2013.10.024>
- Cho, D., & Lee, K. W. (2022). Population Aging and Fiscal Sustainability: Nonlinear Evidence from Europe. *Journal of International Money and Finance*, 126, 102665. <http://dx.doi.org/10.1016/j.jimonfin.2022.102665>
- Croce, E., & Juan-Ramón, H. (2003). Assessing Fiscal Sustainability: A Cross-Country Comparison. *IMF Working Paper No. WP/03/145*. Washington D. C.: IMF. <https://www.imf.org/external/pubs/ft/wp/2003/wp03145.pdf>
- Döring, T., & Oehmke, R. D. (2019). About the Economic Psychology of Public Debt. *Intereconomics*, 54(5), 297-303. <http://dx.doi.org/10.1007/s10272-019-0842-z>
- Guellec, D., & Wunsch-Vincent, S. (2009). Policy Responses to the Economic Crisis: Investing in Innovation for Long-Term Growth. *OECD Digital Economy Papers No. 159*. Paris: OECD Publishing. https://www.oecd-ilibrary.org/science-and-technology/policy-responses-to-the-economic-crisis_222138024482

- IMF. (2023). *Public Finances in Modern History*. Retrieved 1. 8. 2023 from IMF: <https://www.imf.org/external/datamapper/datasets/FPP>
- Krejdl, A. (2006). Fiscal Sustainability - Definition, Indicators and Assessment of Czech Public Finance Sustainability. *Czech National Bank Working Paper Series 3*. Prague: Czech National Bank. https://www.cnb.cz/export/sites/cnb/en/economic-research/.galleries/research_publications/cnb_wp/cnbwp_2006_03.pdf
- Mauro, P., Romeu, R., Binder, A., & Zaman, A. (2015). A Modern History of Fiscal Prudence and Profligacy. *Journal of Monetary Economics*, 76, 55-70. <http://dx.doi.org/10.1016/j.jmoneco.2015.07.003>
- Nzimande, N., & Ngalawa, H. (2019). Fiscal Policy Sustainability in SADC Countries. *African Finance Journal*, 21(1), 86-97. <https://journals.co.za/doi/abs/10.10520/EJC-16fb275d5b>
- OECD (2013). *Government at a Glance 2013*. Paris: OECD. http://dx.doi.org/10.1787/gov_glance-2013-en

