

Fiscal sustainability in BRICS countries: evidence from asymmetric unit root test augmented with Fourier function

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Abstract:

The study's main focus is to demonstrate the importance of accounting for nonlinearities and unobserved structural breaks in testing for stationarity in fiscal budgets. This is achieved by applying the KSS unit root tests augmented with a flexible Fourier form to the fiscal budgets of BRICS countries. We find that when unit root tests do not account for structural breaks, the fiscal budgets tend to contain a unit root whereas when structural breaks are considered without accounting for nonlinearities the series are stationary. Simultaneously accounting for asymmetries and unobserved structural breaks more effectively segregates the data into stationary and nonstationary series.

JEL Classifications: C5, H6

Keywords: Fiscal budgets, BRICS countries, nonlinearity unit root test, Flexible Fourier approximation

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1. Introduction

Following the coining of the acronym of BRIC (Brazil, Russia, India and China) by O'Neil (2001) and the subsequent inclusion of South Africa into the bloc in 2010, much research has been dedicated to the BRICS countries as a collective emerging economic force against other powerhouse economic alliances such as the G7 economies. On a global platform, the BRICS countries collectively account for 40 percent of the world's total foreign reserves, 40 percent of the total world's population, 25 percent of the world's land mass, 45 percent of the world's total labour force, 40 percent of the share in world's total merchandise trade and 20 percent of the world's total GDP. Furthermore, the emergence of the contingency reserve agreement (CRA) as well as the recent launching of the BRICS New Development Bank (NDB) which possess as a challenge to the US-dominated World Bank and International Monetary Fund (IMF), has further escalated the optimism for the future dominance of BRICS countries on a global competitive podium.

However, much criticism has been placed on these BRICS economies on account of their dysfunctional public finances, poor government sustainability and high levels of socio-economic inequalities. Therefore, in response to these criticisms, BRICS countries are placing increasing emphasis on investment in human capital to attract foreign investment, increase technology transfer and develop indigenous innovative capabilities (Mostafa and Mahmood, 2015). Such social investment spending will, in turn, require increased government revenue in the BRICS economies which could potentially lead to increases in the already lingering high levels of public debt in these countries if such expenditure is not

met with accompanied increase in non-debt revenue accumulation. It would thus be interesting for policymakers, other academics and even financial analysts to know as to whether or not fiscal budgets are sustainable in BRICS countries.

Currently, there exist a number of studies which have investigated the sustainability of fiscal budgets for BRICS economies (see Baffes & Shah (1994) and Ewing & Payne (1998) for Brazil, Dhanasekaran (2001) for India, Li (2001) for China and (Nyamongo, Sichei, & Schoeman (2007), Ndahiriwe & Gupta (2010) and Phiri (2018) for South Africa). Despite the ever-expanding empirical research on the revenue-expenditure nexus, there are a number of hiatuses that can be identified from the current literature concerning BRICS countries. For instance, with the exception of Phiri (2018), the remaining studies have assumed linearity in their empirical process. However, as demonstrated by Ewing et. al. (2006), this may be too restrictive in accounting for the dynamic evolution of the fiscal budget. Moreover, there appears to be no existing empirical literature investigating the integration properties of the fiscal budget as a time series for BRICS countries. Lastly, and on a broader level, there are no studies which exist, to the best of our knowledge, we have combined nonlinear unit root testing which account for unobserved structural breaks. This last point is very important considering that over the last decade the world economy has hit by a global financial crisis as well as recessionary period which require empirical analysis to account for such structural breaks.

In our paper, we challenge these shortcomings by employing the nonlinear unit root testing procedure of Kapetanois et al. (2003) (hereafter KSS) augmented with a flexible Fourier function (FFF) to test the integration properties of fiscal budgets in BRICS economies. Essentially FFF are low frequency components from a Fourier approximations which are capable of capturing one or more structural breaks (Enders & Lee, 2012). Moreover, FFF based unit root tests circumvents common problem of selecting structural break dates, the number of appropriate dates and the form of these structural breaks. Hence FFF based unit root tests are gaining increasing popularity in more recent literature as other unit root tests account for endogenous breaks which consider a maximum of two structural breaks (see Lee & Strazicich (2004, 2013)) due to fear of losing regression power.

Against this background, we organize the remainder of the paper as follows. Section 2 of the paper presents the methodology used in the paper. The data and empirical analysis of the study is provided in the third section of the paper. The study is then concluded in the fourth section of the paper.

2. Empirical framework

Theoretically, Hamilton & Flavin (1986) and Hakkio & Rush (1991) argue that a sustainable fiscal budget is consistent with the notion that fiscal authorities should run a sequence of discounted future non-interest budget surpluses capable of offsetting the budget deficit. The analytical framework backing these propositions is based on the following budget constraint:

$$BUD_t = (GE_t + iBUD_{t-1}) - REV_t \quad (1)$$

With BUD_t being government debt, GE_t being real government expenditure exclusive of interest payments, REV_t are real tax revenues and i_t is the real interest rate which is assumed to be a stationary process around a mean of i^* . By defining $EXP_t = GE_t + (i_t - i^*)BUD_{t-1}$, and applying forward substitution results in the following intertemporal budget constraint:

$$BUD_0 = \Pi (REV_{t+j+i} - EXP_{t+j+i}) + \lim_{j \rightarrow \infty} \Pi BUD_{t+j+i} \quad (2)$$

Where $\Pi = \sum_{j=0}^{\infty} (\frac{1}{1+i})^{j+1}$. Sustainability of a budget deficit occurs when:

$$\lim_{j \rightarrow \infty} \Pi BUD_{t+j+i} = 0 \quad (3)$$

That is when current outstanding debt/deficit can be offset by a sequence of discounted future non-interest budget surpluses (Lau & Baharumshah, 2009). The sustainability condition of equation (3) implies that the fiscal budget is stationary over the long-run and does not contain a unit root. If the fiscal budget contains a unit root, then equation (3) does not hold and government will most likely finance its expenditure by issuing new debts to finance deficits. As previously mentioned, our study deviates from conventional unit root testing procedures and uses the KSS nonlinear unit root test. The procedure begins with specifying the following ESTAR model:

$$\Delta BUD_t = \phi_i BUD_{t-1} + \gamma_i BUD_{t-1} [1 - \exp(-\Phi \gamma_i^2)] + \sum_{j=1}^p \rho_i \Delta BUD_{t-i} + e_t \quad (4)$$

And imposing $\phi = 1$, results in the following ESTAR test regression:

$$\Delta BUD_t = \gamma_i BUD_{t-1} - 1 [1 - \exp(-\Phi \gamma_i^2)] + \sum_{j=1}^p \rho_i \Delta BUD_{t-i} + e_t \quad (5)$$

From equation (5), a straightforward method of testing for unit roots would be to test the following null hypothesis $H_0: \Phi = 0$, which is problematic due to inference problems caused by the unidentified γ parameter (i.e. Davies (1987) problem). Therefore, the following auxiliary regression is used:

$$\Delta BUD_t = \delta_i BUD_{t-i}^3 + \sum_{j=1}^p \rho_j \Delta BUD_{t-i} + e_t \quad (6)$$

Where the null hypothesis of a linear unit root process can be now tested as $H0: \delta_i = 0$ against the alternative of stationary ESTAR process (i.e. $H1: \delta_i \neq 0$) and the asymptotic critical value of the Kapetanios et al. (2003) unit root test is computed as:

$$t_{NL} = \frac{\hat{\delta}}{S.E.(\hat{\delta})} \quad (7)$$

Where $\hat{\psi}$ is the estimated value of ψ and $S.E.(\hat{\psi})$ is the standard error of $\hat{\psi}$. Since the t_{NL} statistic does not follow an asymptotic normal distribution, Kapetanios et al. (2003) derive critical values for the test statistics for the test performed on raw time series. Moreover, in the same vein as Enders & Lee (2012) and Rodrigues & Taylor (2012), we augment the KSS test regression (6) with a single frequency flexible Fourier form (FFF) which results in the following test regression:

$$\Delta BUD_t = \delta_i BUD_{t-i}^3 + \sum_{j=1}^p \rho_j \Delta BUD_{t-i} + a_i \sin\left(\frac{2\pi Kt}{T}\right) + b_i \cos\left(\frac{2\pi Kt}{T}\right) + e_t, \quad (8)$$

$$t = 1, 2, \dots, T.$$

Where K is the singular approximated frequency selected for the approximation, whilst coefficients a and b measure the amplitude and displacement of the sinusoidal. Enders & Lee (2012) propose that regression (12) be estimated for all integer values of K which lie between the interval $[1, 5]$ and selecting the estimation which produces the lowest sum of squared residuals (SSR).

3. Data and empirical results

3.1. Empirical data

All empirical data used in our study has been collected from the World Bank online statistical database. Our particular dataset consists of the total government revenue (GR) and total government expenditure (GE) time series variables which has been collected on annual basis for Brazil (1980-2016), Russia (1999-2016), India (1974-2016), China (1982-2016) and South Africa (1972-2015). A third time series variable, the fiscal budget (FB) has been computed as the difference between total government revenue and total government expenditure i.e. $FB = GR - GE$.

3.2. Conventional unit root tests

In starting off our empirical analysis, we firstly perform the convention unit root tests (i.e. ADF, PP and DF-GLS tests) on the observed time series and report the results in Table 1. Regardless of whether the ADF and PP unit root tests are performed with a drift or with a

drift and trend, the unit root null hypothesis cannot be rejected for all BRICS countries. Similarly, when the DF-GLS test is performed with a drift, the unit root null hypothesis is unanimously rejected for all countries whereas when a trend is added to the test, only Russia and South Africa manage to significantly reject the null hypothesis in favour of stationarity at 5 percent and 10 percent critical levels, respectively. However, without having accounted for structural breaks in the KSS regression heightens the likelihood of obtaining spurious regressions as has been initially cautioned by Perron (1989).

TABLE 1. CONVENTIONAL UNIT ROOT TEST RESULTS

Country	ADF		PP		DF-GLS	
	int	int + trend	int	int + trend	int	int + trend
Brazil	-2.21	-2.02	-1.93	-1.64	-0.91	-1.42
Russia	0.54	-2.98	-1.44	-2.41	-1.59	-3.27**
India	-1.85	-1.81	-1.85	-2.01	-1.86	-1.92
China	-1.62	-1.92	-1.74	-2.05	-1.39	-2.09
S.A.	-2.93	-2.99	-2.78	-2.74	-2.97	-3.07*

Notes: "****", "***", "**" represent the 1%, 5% and 10% significance levels, respectively. Optimal lag lengths for the ADF and DF-GLS test are based on minimization of AIC and SC information criterion.

3.3. Unit root tests with exogenous structural shifts

Table 2 presents the empirical findings the LM structural break tests proposed by Lee & Strazicich (2004, 2013), with Panel A reporting the test results for the single break tests Lee & Strazicich (2013) and Panel B reporting those for the double break tests Lee & Strazicich (2004). Both tests are performed by setting a maximum of 6 lags on the tests and working the lags down until the AIC and SC information criterion are minimized. As can be observed from Table 2 all performed tests manage to reject the unit root null hypothesis in favour of stationarity of the budget processes at all critical levels for all countries with the exception of the double-structural break unit root test performed for the South African series, in which unit root null hypothesis cannot be rejected. Notice that the identified break dates correspond to important economic and political events such as the cold war period of 1980 to 1985 for Russia, the democratic political transition of the South African economy in 1994 to 1995, the Asian financial crisis of 1998-1999 which greatly affected China and India as well as the Latin fiscal and currency crisis experienced during the 1980's.

TABLE 2. LEE & STRAZICICH (2004, 2013) ENDOGENOUS STRUCTURAL BREAK TESTS

Country	Panel A: LS(one break)			Panel B: LS(two breaks)			
	LM-stat	Break point	lag	LM-stat	Break point		Lag
					Break1	Break2	
Brazil	-5.58***	1991	6	-5.32***	1985	1990	7
Russia	-9.56***	1984	6	-6.79***	1980	1985	4
India	-5.49***	1998	7	-6.48***	1990	2000	8
China	-5.00***	1998	3	-8.87***	1987	2000	8
S.A.	-4.59**	1995	2	-5.13	1988	2003	8

Notes: "****", "***", "**" represent the 1%, 5% and 10% significance levels, respectively.

3.4. Panel KSS test with FFF

In this section of the paper, we extend on the previous analysis by incorporating nonlinearities into the picture. In order to do so, we estimate the KSS regression for our sample data and we particularly estimate two variations of the test regression for each of the BRICS countries. The first estimated regression represents the KSS test performed without a FFF (no structural breaks) as reported in Panel A of Table 3. The second regression is the KSS test augmented with a FFF (unobserved structural breaks) as reported in Panel B of Table 3. When the test is performed without a FFF, then the test statistics produced for all countries exceed their 10 percent critical levels, hence providing evidence of fiscal budgets containing a unit root. Nevertheless, only the fiscal budgets for Indian and China reject the unit root hypothesis, whilst for the remaining countries (Brazil, Russia and South Africa) the test statistic reject the unit root null hypothesis at all levels of significance.

TABLE 3. KSS UNIT ROOT TEST RESULTS WITH AD WITHOUT FFF

Country	Panel A: KSS test		Panel B: KSS tests with FFF		
	t-stat	Optimal lags	t-stat	K	Optimal lag
Brazil	-1.41	1	-2.98***	5	6
Russia	-0.61	1	-3.31***	5	6
India	-1.69	1	-0.60	5	6
China	-0.31	1	-1.14	1	6
S.A	-1.85	1	-3.00***	1	6

Note: "****", "***", "**" represent the 1%, 5% and 10% significance levels, respectively. The critical values associated with KSS tests performed on the raw data are -2.82 (1%), -2.22(5%) and -1.92 (10%) and the optimal lag lengths for the tests are based on minimization of AIC and SC information criterion. Optimal frequency approximation, K^* , is selected via a minimization of the SSR.

4. Conclusions

This study sought to contribute to the ever-expanding empirical literature on the sustainability of the fiscal budget for BRICS economies. In differing from previous studies for BRICS countries, we control for both asymmetries and unobserved structural breaks by utilizing the nonlinear panel KSS unit root test augmented with a flexible Fourier function. However prior to the estimation of these models, we perform a preliminary analysis through conventional unit root testing procedures which do not account for nonlinearities and structural breaks as well as through endogenous LM tests which account for up to two structural breaks. These preliminaries indicate that when structural breaks are not accounted for, the fiscal budgets in BRICS countries largely contain a unit root whilst when endogenous structural breaks are accounted for then the series turns stationary. However, when both asymmetries and unobserved structural breaks are accounted for, only India and China contain a unit root in their fiscal budgets (unsustainable) whilst the budgets for Brazil, Russian and South Africa are stationary (sustainable). Our study therefore emphasises on the importance of accounting for both asymmetries and unobserved structural breaks in examining the integration properties of fiscal budgets and paves a way for future studies to follow for other emerging or industrialized economies.

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