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FISCAL SUSTAINABILITY IN EMERGING MARKETS: PANEL UNIT ROOT APPROACH WITH SMOOTH STRUCTURAL SHIFTS AND COMMON FACTORS

Gelişmekte Olan Piyasalarda Mali Sürdürülebilirlik: Yumuşak Yapısal Değişimler ve Ortak Faktörler ile Panel Birim Kök Yaklaşımı

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Fiscal Sustainability, Emerging Markets, Fourier Shifts, Common Factors, Panel Unit Root.

JEL Codes:
C23, E62, H61.

Abstract

We test the fiscal sustainability in emerging markets (EMs) for a period of nearly half a century (1970-2022) using the panel unit root approach with common factors and Fourier breaks through the government budget balance. We also provide an opportunity for comparison by applying a method that considers sharp-type breaks under common factors. The outcomes of the sharp-type break test report that the budget structure in EMs is unsustainable at both the panel and cross-sectional levels. On the contrary, evidence from the Fourier break test confirms fiscal sustainability at the panel level and for six countries (Indonesia, Peru, the Philippines, South Africa, Thailand, and Türkiye). The paper advocates that in samples such as EMs with many breaks, sharp-break approaches are inadequate to explain the data structure. These differing analysis findings highlight that Fourier break approaches are strong candidates to fill this gap in the empirical literature. Lastly, the paper offers policy recommendations based on the findings generated by the new approach.

Anahtar Kelimeler:
Mali Sürdürülebilirlik, Gelişmekte Olan Piyasalar, Fourier Kırılımlar, Ortak Faktörler, Panel Birim Kök.

JEL Kodları:
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Öz

Gelişmekte olan ülkelerde (GOÜ) mali sürdürülebilirliği hükümet bütçe dengesi üzerinden, yaklaşık yarım asırlık bir dönem (1970-2022) için, ortak faktörler ve Fourier kırılmaları içeren panel birim kök yaklaşımıyla test ediyoruz. Ayrıca, ortak faktörler altında keskin tip kırılmaları dikkate alan bir yöntem uygulayarak karşılaştırma imkanı sağlıyoruz. Keskin tip kırılma testinin sonuçları, GOÜ'lerde bütçe yapısının hem panel hem de yatay kesit düzeyinde sürdürülemez olduğunu ortaya koymaktadır. Buna karşın, Fourier kırılma testi, panel düzeyinde ve altı ülke (Endonezya, Peru, Filipinler, G. Afrika, Tayland ve Türkiye) için mali sürdürülebilirliği doğrulamaktadır. Çalışma, GOÜ gibi çok sayıda kırılmanın olduğu örneklerde, keskin kırılma yaklaşımlarının veri yapısını açıklamada yetersiz kaldığını savunmaktadır. Farklı analiz bulguları, Fourier kırılma yaklaşımlarının ampirik literatürdeki bu boşluğu doldurmak için güçlü adaylar olduğunu vurgulamaktadır. Son olarak, makale yeni yaklaşımla elde edilen bulgulara dayalı politika önerileri sunmaktadır.

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1. Introduction

In this century, both national and supranational institutions attribute great importance to sustainability. The United Nations (UN), which has a leading role among these institutions, has set various sustainable development goals to address humanity's present and future challenges (UN, 2024). However, achieving the sustainability goals set in many areas, such as education, health, employment, and the environment, depends on the sources of financing, namely the budget structure. This link brings up the question of whether the budget balance is sufficient for many government goals. Therefore, the challenges associated with goals encourage researchers to build empirical evidence on budget proxies.

In the public sector, fiscal sustainability refers to the ability of governments to meet their fiscal responsibilities in the long run (Chapman, 2008). According to another definition, fiscal sustainability refers to the ability to finance the government budget without sharp and dramatic increases in public debt or the money supply (Adams et al., 2010). Ensuring fiscal sustainability is a necessary condition for a long-term expenditure-income relationship and a stable macroeconomic process. Otherwise, budget imbalances or persistent budget deficits complicate economic conditions and limit the space for governments to act (Afonso and Jalles, 2016). For this reason, politicians are trying to take measures to ensure fiscal sustainability at the global, regional, and/or national scale. For instance, according to the Maastricht Criteria, public deficit should not exceed 3% of GDP (European Commission, 2024).

The sustainability of fiscal policies plays a critical role in both macroeconomic balances and public policies. The main objectives of fiscal sustainability are managing budget deficits and increasing primary budget surpluses. However, major exogenous shocks and domestic/international politics turn this process into a complex constrained optimization problem (Brady and Magazzino, 2018). Hence, analyzing the impact of internal and external shocks on the budget balance and understanding the characteristics and consequences of budget balance movements due to shocks can contribute to ensuring fiscal sustainability.

In economic literature, unit root analysis is used to examine the nature of shocks to any indicator. This approach provides an econometric framework for investigating the persistence of shocks. Accordingly, permanent shocks to the budget balance indicate a unit root process. This result reveals the weakness of fiscal policies and the need for policy changes in macro-/micro-level economic policies. On the other hand, if the shocks to the budget balance are temporary, deviations from the budget balance tend to return to their average over time. In such a case, no change in the current policy behavior is required for sustainable fiscal policies (Afonso and Jalles, 2014). In this context, examining the structure of shocks to the budget balance by unit root tests guides the budget policies of governments. In the field of fiscal sustainability, there are many papers in the unit root literature pioneered by Hamilton and Flavin (1986) and Trehan and Walsh (1991) (see Table 1).

The paper focuses on the emerging markets (EMs) as a sampling. Playing a critical role in terms of sustainability goals, EMs represent about half of the global population (51.3% in 2023) and economy (46% in 2023) (IMF, 2024a; World Bank, 2024). EM countries experience many shocks and are more unstable than developed countries highlights the need for methods that can model breaks in the analysis. For example, according to average statistics from 1995 to the present, economic growth, unemployment, and inflation rates in EMs are 64.5%, 20.1% and 161% higher, respectively, than in developed countries. Moreover, 62% of EM countries had a

current account deficit during this period, while this ratio was 39% in developed countries (IMF, 2024a). Finally, according to the Worldwide Governance Indicators (WGI) for the period 1996-2022, political stability in EMs was 39.7% lower than in developed countries (WGI, 2024)[1]. Notwithstanding high growth rates, the economic and political indicators above show that EM economies are more fragile compared to developed countries, and this fragility poses a threat to public finances. The presence of multiple economic and political instabilities poses a threat to budget sustainability in EMs. For this reason, governments can build sustainable fiscal structures by analyzing budget balance shocks in EMs through unit root tests and providing policy implications.

The paper analyses the 1970-2022 period for 14 EMs, which are determined according to data availability, by using panel data econometrics with annual data. As panel data econometrics takes into account both the cross-sectional and time dimension in the data set, the size and power characteristics of the test increase[2]. Since time series analyses focus on a single sample, they neglect common factors influenced by or affecting the sample. However, many factors, such as relationships in supply and demand structure, similarities in local market conditions, political events, technological innovations, geopolitical risks, and seasonal effects, may lead countries to exhibit a common trend in macro indicators. For a similar problem in the field of fiscal sustainability, Afonso and Rault (2010) emphasize the tendency for observations on regions or countries to be cross-correlated and dependent. For this reason, researchers attempt to question the interactions and complex interdependencies between units (countries, etc.) with panel methods that consider cross-sectional dependence (Afonso and Rault, 2010). In this respect, it is important to take into account the impact of common factors when analyzing the sustainability of the budget balance. Based on this information, we consider common factors in testing the persistence of shocks to the budget balance. To provide comparative findings, we use the PANIC-with sharp breaks test, which considers sharp breaks under common factors, and a more recent version of this test, the PANIC-with Fourier breaks test, which considers Fourier breaks. The main focus of the study, however, is the PANIC-with Fourier breaks test developed by Nazlioglu et al. (2023). This is because focusing on Fourier breaks under common factors offers significant advantages[3]. Overall, the research question of the paper is: "*Is the budget*

[1] MSCI (2024) is considered for the classification of countries in comparisons between EMs and developed countries.

[2] Panel data has a higher number of observations compared to cross-sectional and time-series data since it is formed with both cross-sectional and time dimensions. This allows for a more comprehensive and in-depth analysis and more robust results. Panel data can take into account unobserved heterogeneity. It can control for individual characteristics that do not change over time but affect the budget balance, such as geographical location or infrastructure. Governments may implement different fiscal balance policies (taxes, price ceilings, subsidies, etc.) in different regions or at different times. Panel data analysis can help assess the effects of such policies while controlling for other factors (Baltagi, 2008; Wooldridge, 2010; Wang, 2022). Therefore, panel data analysis provides significant advantages in analyzing the behavior of the sustainability of the fiscal balance.

[3] Sharp, logistic smooth transition autoregressive (LSTAR) or exponential smooth transition autoregressive (ESTAR) break types are difficult to capture using standard break testing methodologies. At this point, the Fourier approach has the flexibility to model all types of breaks with trigonometric variables and smooth transition functions (Enders and Lee, 2012:574). Fourier functions allow for asymmetries in the rate of return to the mean (Christopoulos and León-Ledesmai, 2010). Capturing budget balance breaks as a smooth process is more useful for understanding the evolution over time and the cyclical nature of shocks to fiscal discipline. Because, while the sharp break framework is successful in modelling the impact of the economic crisis period on fiscal discipline, it is insufficient in capturing the cyclical effects of these breaks over time. Moreover, the digitization anchor of fiscal discipline,

balance of 14 EMs sustainable between 1970 and 2022, considering common factors and Fourier breaks?"

According to the findings, the fiscal balance has a unit root process in the panel dimension under sharp breaks, i.e., the fiscal balance is unsustainable for EMs, whereas when Fourier breaks are taken into account, the budget balance tends to return to its average, i.e. there is a sustainable fiscal balance for EMs. Moreover, when the cross-sectional results are analyzed, there is no sustainable structure for any country according to the PANIC-with sharp breaks test, while according to the PANIC-with Fourier breaks test, there is a sustainable structure for approximately half of the sample.

This paper aims to contribute to the literature in three ways. Firstly, despite the existence of papers on country classifications such as the EU, the OECD, and the G7 in the literature on fiscal sustainability based on unit root methods, there is a gap for EM countries (see Table 1). This paper differs from the literature by producing both panel and country-specific results for EMs. Secondly, this paper explores a period of about half a century for EMs. In developed countries, researchers have access to a large historical data on the public sector thanks to institutionalization, reporting systems, transparency, technical infrastructure, qualified human capital, and so on. However, these features are largely not applicable to EMs. Hence, this paper attempts to fill the gap in the literature by analyzing a broad period for EMs where data availability is limited. Thirdly, this paper is the first attempt to account for fiscal sustainability under common factors with smooth breaks. In this context, we provide a new perspective to the literature on fiscal sustainability using the PANIC-with Fourier breaks testing methodology.

The rest of the paper is structured as follows: The second section presents the theoretical perspective of fiscal sustainability and a survey of empirical literature. The third section describes the methodology for the Nazlioglu et al. (2023) approach. The fourth section explains the EMs dataset. The fifth section offers a comparative analysis of the findings of the two approaches. The last section evaluates the fiscal structure for EMs in light of the empirical findings and provides policy recommendations.

2. Theoretical Background and Literature Review

In the literature, fiscal sustainability analyses are divided into two approaches. First, in the so-called accounting approach to budget deficit, researchers analyze fiscal sustainability with the help of indicators. The other approach is the intertemporal budget deficit constraint/present value constraint, where researchers apply empirical tests (Sen et al., 2010). The paper prefers the second approach, as it aims to generate empirical evidence on fiscal sustainability. Hakkio and Rush (1991) model the one-period budget constraint by Equation 1:

$$G_t + (1 + i_t)B_{t-1} = R_t + B_t \quad (1)$$

where $G_t$is real government expenditures, $R_t$is real government revenues, B_tt is real government debt, i_t is real interest rate and t is the time dimension. With the help of Equation 2, the transformation of the one-period budget constraint into an intertemporal budget constraint is as follows:

institutionalization, and a performance-based budget system may affect the fiscal balance gradually. These smooth transition processes can also be better modelled in Fourier form.

$$B_0 = \sum_{t=1}^{\infty} r_t \, (R_t - G_t) + \lim_{n \to \infty} r_n \, B_n \tag{2}$$

The most important element in Equation 2 is $\lim_{n\to\infty} r_n \, B_n$. Here, if the limiting value of $r_n B_n$ is equal to zero, the possibility of financing the budget deficit by issuing new debt disappears. Otherwise, old debt is financed by new debt issuance, and the budget deficit enters a growth cycle (Hakkio and Rush 1991).

In the literature, unit root methods are mostly applied for testing the validity of fiscal sustainability. Following the budget constraint approach of Trehan and Walsh (1991), the budget balance is assumed to have a stationary process to ensure the sufficient condition. According to Equation 3, if budget balance (BB is the budget balance) has a stationary process, fiscal sustainability is valid. The presence of a random walk process in the budget balance implies that fiscal sustainability is invalid.

$$BB_t = B_t - B_{t-1} \tag{3}$$

In addition to unit root tests, fiscal sustainability is also assessed by cointegration tests. According to Equation 4 (a is the constant term, β is the slope coefficient, and ε_t is the error term), the cointegration relationship between R_t and G_t is investigated with the help of the β coefficient. β=1 indicates strong fiscal sustainability, while 0<β<1 points to weak fiscal sustainability (Hakkio and Rush 1991; Quintos, 1995; Afonso, 2005).

$$R\_t = a + \beta G\_t + \varepsilon\_t \tag{4}$$

This article examines fiscal sustainability through unit root tests using the government budget balance indicator, following to the preliminary literature (see, Hamilton and Flavin, 1986; Trehan and Walsh,1988; Wilcox, 1989; Kremers, 1989; Trehan and Walsh, 1991).

In the unit root-based fiscal sustainability literature, some researchers prefer various indicators such as government expenditures, government revenues, government debt, as well as government budget balance (see Quintos, 1995; Cipollini, 2001; Goyal et al., 2004; Lusinyan and Thornton, 2009; Westerlund and Prohl, 2010; Afonso and Jalles, 2015; Chen, 2016; Baharumshah et al., 2017; Magazzino et al., 2019; Afonso and Alves, 2023). However, none of these indicators, except the government budget balance, has the capacity to represent public finance on its own. On the other side, cointegration tests generally focus on the mutual reactions of government expenditures and government revenues. However, the government budget balance, which represents fiscal sustainability in this paper, is a comprehensive outcome of all public finances, including government expenditures and revenues. In other words, this indicator is determined by the behavior of government revenues, consisting of components such as taxes, domestic/foreign debt, fees, earnings of public economic enterprises, and government expenditures, consisting of current, investment, and transfer expenditures. Therefore, the motivation of the paper is to explore fiscal sustainability with the help of the strongest indicator reflecting the public sector.

Although researchers have used different methods to investigate fiscal sustainability, studies are generally clustered around unit root and cointegration tests. We focus on the unit root wing of the related literature. Table 1 provides a summary of the literature examining fiscal sustainability in terms of unit root properties. Based on Table 1, we observe that the literature investigating fiscal sustainability with unit root tests evolves in line with the development of

empirical methods. The first papers in this area sought answers with conventional unit root tests (Hamilton and Flavin, 1986; Trehan and Walsh, 1988; Kremers, 1989; Vanhorebeek and Van Rompuy, 1995; Getzner et al., 2001; Collignon, 2012; Al Sayed et al., 2021; Afonso and Coelho, 2024). In the following period, some researchers applied unit root tests that take into account structural breaks and nonlinear distributions to better explain local and global economic dynamics in the light of the developing empirical literature (Makrydakis et al., 1999; Boengiu et al., 2011; Chen, 2014; Chibi et al., 2019; Saadaoui et al., 2024). However, these tests, which can explain limited breaks, may produce misleading evidence, especially for countries with stability problems. Therefore, this study opens a new window in the empirical fiscal sustainability literature by choosing a novel test that does not neglect Fourier breaks and common factors. Moreover, the papers in Table 1 emphasize the preponderance of empirical evidence for developed countries/country groups such as the US, the EU, and the G7 compared to EMs. This paper also contributes to the sample gap in the fiscal sustainability literature by providing evidence for EMs suffering from instability.

Table 1. Summary of the Literature for Fiscal Sustainability

Author	Country/Period	Variable	Methodology	Existence of Fiscal Sustainability
Vanhorebeek and Van Rompuy (1995)	8 EU Countries 1970-1994	GD, BB	Unit root: ADF and KPSS	For Germany, France, and Denmark: ✓ For Italy, Belgium, Ireland, Netherlands, and UK: X
Makrydakis et al. (1999)	Greece 1958-1995	GD	Unit root: ZA	X
Feve and Henin (2000)	G-7 Countries	GD	Unit root: FADF Regression: AR-OLS	For USA, UK, and Japan: ✓ For Germany, France, Italy, and Canada: X
Getzner et al. (2001)	Austrian 1960-1999	GD	Unit root: ADF and PP	For the period 1960-1974: ✓ For the period: 1975-1999: X
Arestis et al. (2004)	USA 1947M02-2002M01	BB	Unit root: TAR	✓
Marks (2004)	Indonesia 1991-2003	GD, GR, GE	One-period primary gap	✓
Ghatak and Sanchez-Fung (2007)	Peru, Philippines, South Africa, Thailand, Venezuela 1970-2000	GR, GE, GD, Output, Price, Population	Unit root: DF Co-integration: Engle Granger	For Thailand: ✓ The results for the Philippines and South Africa The results vary by year, and for Peru and Venezuela quite weak.
Boengiu et al. (2011)	Romania 1990Q4-2010Q4	GD	Unit root: QUR	X
Afonso and Jalles (2012)	18 OECD Countries 1970-2010	GD, GR, GE, Primary BB	Unit root: ADF, PP, ZA, and CMR. Co-integration: Johansen/Juselius/Stock-Watson-Shin/ FMOLS Causality: Granger/Toda-Yamamoto/Pedroni	For Austria, Canada, France, Germany, Japan, Netherlands, Sweden, and UK: ✓ For the rest: X
Collignon (2012)	14 EU Countries 1978-2009	GD	Unit root: Panel ADF Stationary: Panel KPSS	For all countries: ✓
Chen (2014)	G-7 and 4 EU Countries 1980Q1-2012Q4	GD	Unit root: Nonlinear Unit Root Tests (TAR, MTAR, LSTAR)	For Canada, Germany, US, and Italy: ✓ For the rest: X
Apergis (2015)	5 EU Countries 1980-2014	GD	Unit root: Lee and Strazicich LM, NP, and NL-GARCH	For Ireland and Portugal: ✓ For Greece, Italy, and Spain: X

Table 1. Continued

Cuestas and Regis (2018)	China 1992Q1-2016Q1	GD	Unit root: KSS	For the until 2014: ✓
Chibi et al. (2019)	Algeria 1964Q1- 2016Q1	GD	Unit root: ADF, PP, KPSS, STAR, ZA, LS, and SL	X
Campos and Cysne (2020)	Brazil 1997:M12-2018:M06	GD	Multicointegration	X
Polat and Polat (2021)	26 EU and PIIGS Countries 1995-2018	BB, GD, GR, GE, Business Cycle	Unit Root: CD, CADF Co-integration: Westerlund Regression: CCEMG	For 26 EU: ✓ For PIIGS: X
Sayed et al. (2021)	Egypt 1990-2018	Primary BB, Tax Burden, Tax Gap, GR, GD	Unit root: ADF Co-integration: Johansen	✓
Rajakaruna and Suardi (2022)	Sri Lanka, India, Pakistan 1960-2019	BB, GD,	Threshold Regression	✓
Deheri and Nag (2023)	India 1980-1981 to 2019-2020	GD, GR, GE, Interest Rate, GDP	Co-integration: ARDL	✓
Yavuz et al. (2023)	Türkiye 1960-2022	GE, GR, GD	Unit root: ADF, RALS-ADF, KSS, FADF, FKSS, QKS, FQKS, NQKS, and FNQKS	GE: KSS, FQKS, and FNQKS ✓ GR: FNQKS ✓ GD: RALS-ADF, QKS, FQKS, NQKS, and FNQKS ✓
Saadaoui et al. (2024)	6 OECD Countries 1870-2017	GD	Unit root: Fourier DF Regression: OLS	For UK, Sweeden, USA: X (Equivocal for Canada, Italy, and Portugal)
Afonso and Coelho (2024)	Portugal 1999Q4-2021Q4	GR, GD, GE, Primary BB	Unit root: ADF and PP Co-integration: Johansen/Juselius	✓
Chekouri et al. (2024)	4 Nort African Countries 1964-2021	GD	Unit root: GSADF, QUR	For all countries: X
Shah et al. (2025)	76 Countries 1996-2020	BB, GD, GDP, Inflation	Panel unit root: ADF, PP Quantile regression OLS, System GMM	For Pakistan, Sri Lanka, Sudan, and Uganda: X The rest Countries: ✓

Notes: * GD: Government Debt, GE: Government Expenditure, GR: Government Revenue, BB: Budget Balance[4]. ** ADF: Augmented Dickey-Fuller, CMR: Clemente, Montanes and Reyes, FADF: Fourier ADF, FKSS: Fourier Kapetanios-Shin-Snell, FNQKS: Fourier Non-linear Quantile Kolmogorov-Smirnov, FMOLS: Fully Modified Least Squares, FQKS: Fourier QKS, GSADF: Generalized Supremum ADF, QUR: Quantile Unit Root, KPSS: Kwiatkowski–Phillips–Schmidt–Shin, KSS: Kapetanios-Shin-Snell, LS: Lee and Strazicich, NL: Narayan and Liu, NP: Narayan and Popp, NQKS: Non-linear QKS, PP: Phillips-Perron, QKS: Quantile Kolmogorov-Smirnov, RALS-ADF: Residual Augmented Least Squares ADF, SL: Saikkonen and Lütkepohl, STAR: Smooth Transition Autoregressive, ZA: Zivot-Andrews, GMM: Generalized Method of Moments, OLS: Ordinary Least Squares. *** X: Fiscal sustainability exists, ✓: Fiscal sustainability does not exist

[4] Some papers use the concept of budget deficit for the budget balance indicator. We use the concept of budget balance for consistency in this paper.

3. Econometric Methodology

We start to define the data generating process as,

$$y_{i,t} = d_{i,t} + \pi_i' F_t + e_{i,t}, \;\; t = 1, \dots, T; \;\; i = 1, \dots, N \tag{5}$$

where F_t is the vector of unobservable common factors in dimension $rx1$. π_i' are the factor loadings that measure the sensitivity of each cross-sectional unit to the influence of common factors. $d_{i,t}$ is the deterministic components (constant/trend) matrix. $e_{i,t}$ is the error term.

Bai and Carrion-i Silvestre (2009) added structural breaks to $d_{i,t}$ in Equation 5 using a dummy variable approach. However, this version assumes that the breaks are sharp and a priori information about the breaks is needed to add them to the model. Nazlioglu et al. (2023) has extended $d_{i,t}$ with a Fourier function that can model structural shifts without requiring any prior information or assumptions and can capture all types of structural changes.

The extended $d_{i,t}$ for Fourier breaks is as shown in Equation 6.

$$d_{i,t} = c_i + \gamma_i t + \sum_{k=1}^{m_i} a_{ik} \cos\left(\frac{2\pi k_i t}{T}\right) + \sum_{k=1}^{m_i} b_{ik} \sin\left(\frac{2\pi k_i t}{T}\right) \tag{6}$$

where c_i and t are the constant term and trend, respectively. k is the number of Fourier frequencies and m is the number of cumulative frequencies. γ_i, a_{ik}, and b_{ik} are regression coefficients.

This method has two important advantages. The first advantage of the method is that it allows for multiple structural breaks in the panel unit root framework, either smooth or gradual. In this way, it has the ability to account for various unknown forms of smooth multiple breaks and nonlinearity. The second advantage is that, under the PANIC procedure, it controls for cross-correlations and heterogeneous structural changes in errors using a dynamic factor model.

Nazlioglu et al. (2023) allow the locations and types of breaks to differ across cross-sectional units. In this way, it allows cross-sectional analyses in addition to the panel dimension. Cross-sectional test statistics are obtained as shown below:

$$\Delta y_{i,t} = \gamma_i + \beta_i \tilde{S}_{i,t-1} + \sum_{k=1}^{m_i} a_{ik} \cos\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^{m_i} b_{ik} \sin\left(\frac{2\pi kt}{T}\right) + \pi_i' \hat{f}_t + \sum_{s=1}^{P_i} c_{is} \Delta \tilde{S}_{i,t-s} + v_{i,t} \tag{7}$$

where the lagged value $\tilde{S}_{i,t}$ is added according to the number of estimated frequencies. $\hat{f}$ represents the factors. $\Delta \tilde{S}_{i,t}$ are lag values added for autocorrelation correction. The null of unit root ($H_0: \beta_i = 0$) for all i's is tested against the alternative of stationarity ($H_a: \beta_i < 0$) for some i's. We first obtain the individual LM unit root statistic for each cross section, denoted by $\tilde{\tau}_i$, which is the t-ratio corresponding to β_i, in order to test the null hypothesis. Then, two panel statistics are constructed, given by

$$P = -2 \sum_{i=1}^{N} ln\tilde{p}_i \sim \chi^2_{2N} \tag{8}$$

$$P_m = \frac{-2 \sum_{i=1}^{N} ln\tilde{p}_i - 2N}{\sqrt{4N}} \sim N(0,1) \tag{9}$$

where $\tilde{p}$ is the p-value of the $\tilde{\tau}_i$. Note that for a convenient implementation of panel statistics and to facilitate inference for cross-sectional units, Nazlioglu et al. (2023) uses a response surface function[5] to obtain the p-value ($\tilde{p}$).

4. Data

This paper analyses 14 EMs (Brazil, Chile, China, Colombia, Greece, India, Indonesia, Korea, Mexico, Peru, Philippines, South Africa, Thailand, and Türkiye) according to the MSCI classification for the period 1970-2022[6]. We investigate fiscal sustainability in the maximum number of countries, respecting the number of observations required for the empirical method. In the empirical models, the share of government budget balance in GDP is used as a proxy variable for fiscal sustainability. Data for all countries are from IMF-Public Finance in Modern History (IMF, 2024b).

Table 2 reports descriptive statistics and pre-test findings. Firstly, descriptive statistics reveal that 8 EMs have budget deficits, and 6 EMs have budget surpluses according to the averages of the analysis period. Brazil has the highest budget surplus at 3.29%, above the EMs average of 0.03%. It is followed by Chile and the Philippines with 1.97% and 1.93% respectively. On the other hand, the countries with the worst performance with respect to the budget balance are India and Greece, with -3.29% and -1.93%, respectively. The data indicate that other countries with negative budget balances have budget deficit ratios below 1%. In addition, the standard deviation data in the descriptive statistics point to high instability in the budget balance in the EMs during the period under review. Moreover, the standard deviation data in the descriptive statistics point to high instability in the budget balance in the EMs during the period under review. The average standard deviation for EMs is calculated as 2.42. While 6 EMs are above the average, 8 EMs are below it. The countries with the highest budget balance instability are Chile (3.88), Greece (3.06), and Türkiye (2.99). Meanwhile, India (1.46), Indonesia (1.67), and Colombia (1.82) have more stable budget balances compared to other EMs.

Secondly, among the descriptive test findings, Jarque-Bera reveals that the data have a non-normal distribution in 5(14) EMs, 6(14) EMs exhibit a right-tailed (S>0) structure, while the others exhibit a left-tailed (S<0). 6(14) EMs have platykurtic (K<3), 8(14) EMs have leptokurtic distribution (K>3). The Ftrig statistic demonstrates that Fourier structural breaks are significant in all EMs and, as can be seen from Figure 1, the budget balance contains structural breaks, and the Fourier approximation, based on k, seems to capture the long fluctuations in the series. Moreover, the number, dates, and forms of breaks seem difficult to know a priori. Because the selected frequency (k^*) is fractional 7(14) proves that structural breaks in EMs have a permanent effect on the series. Moreover, the high volatility in the budget balance in Figure 1 confirms the standard deviation values calculated for EMs. Although this ratio exhibited dramatic changes in different periods for each EM, it experienced large declines during global shocks such as the 2008 Financial Crisis and the COVID-19 pandemic.

[5] For details of the response surface function see Nazlioglu et al. (2023).
[6] To obtain balanced panel data, we use data forecasting for several years in Brazil, Chile and China. Please contact the corresponding author for details on data forecasting.

Table 2. Preliminary Analysis

Countries	DS		Test of Normality				Test of Fourier Breaks		
	M	SD	S	K	JB	p-val.	k*	F-trig	p-val.
Brazil	3.298	2.303	-1.078	6.942	44.578***	0.000	2.2	18.450***	0.000
Chile	1.971	3.881	0.414	3.852	3.115	0.211	1.0	5.477***	0.007
China	-0.364	2.414	-1.173	4.944	20.491***	0.000	1.7	15.069***	0.000
Colombia	-0.159	1.826	-0.036	2.708	0.199	0.905	1.0	11.599***	0.000
Greece	-1.938	3.063	0.033	2.852	0.058	0.971	2.8	13.231***	0.000
India	-3.194	1.465	-0.206	3.372	0.682	0.711	1.0	7.735***	0.001
Indonesia	0.492	1.678	-0.150	2.941	0.207	0.901	1.0	34.740***	0.000
Korea	1.584	1.985	-1.086	3.791	11.798***	0.003	1.0	33.349***	0.000
Mexico	1.825	2.770	1.070	3.186	10.189***	0.006	1.3	22.254***	0.000
Peru	-0.316	2.563	-0.605	3.586	3.986	0.136	1.0	10.182***	0.000
Philippines	1.934	2.154	-0.827	4.006	8.278**	0.016	1.0	13.615***	0.000
South Africa	-0.424	2.179	0.308	2.656	1.102	0.576	1.3	14.273***	0.000
Thailand	-0.119	2.661	0.155	2.919	0.226	0.893	2.7	7.979***	0.001
Türkiye	0.392	2.991	0.418	2.683	1.767	0.413	1.4	29.296***	0.000

Notes: JB refers to Jarque and Bera (1987) test. DS: Descriptive statistics, M: Mean, SD: Standard deviation, S: Skewness, and K: Kurtosis. k* is the Fourier frequency chosen by minimising the sum of squares of the error obtained from the Least Squares (LS) estimation. ***, **, and * denotes the significance level at 1%, 5%, and 10%, respectively.

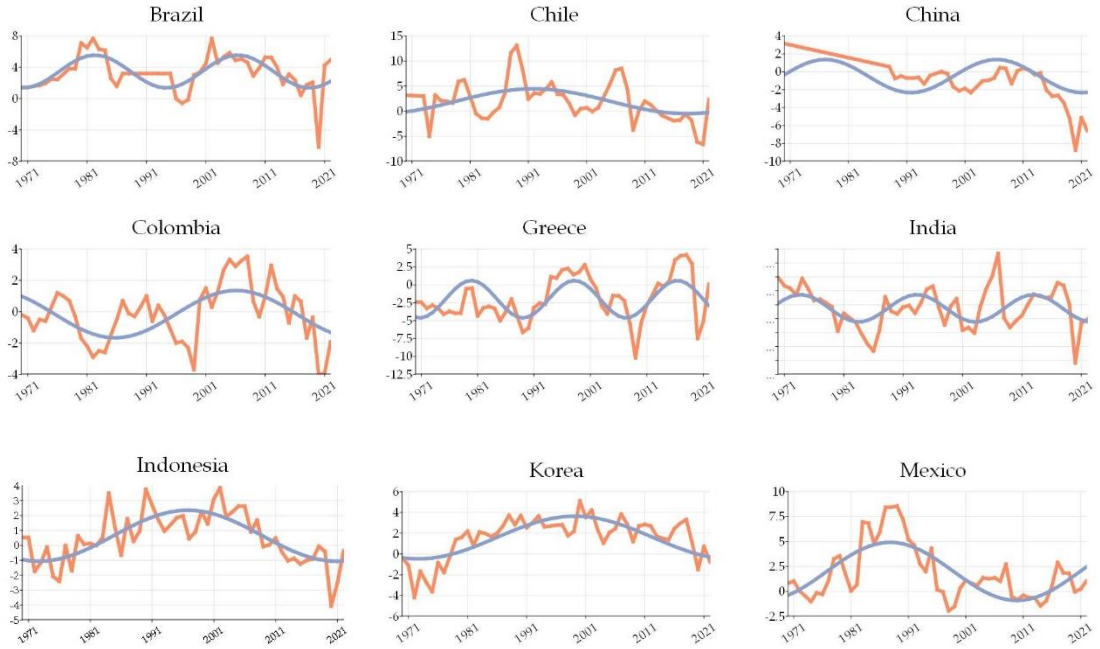

Figure 1. Budget Balance and Fitted Fourier Approximations

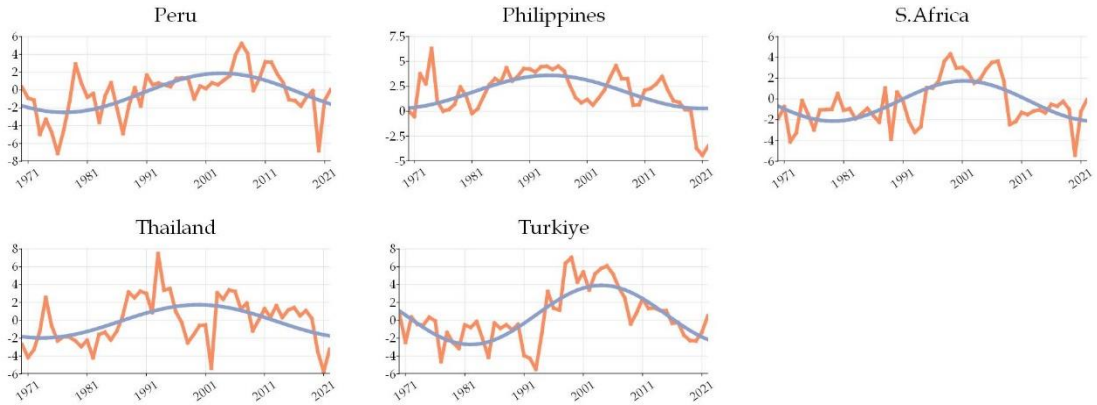

Figure 1. Continued

5. Findings and Discussion

We test the sustainability of fiscal balance in EM countries by taking into account common factors and structural breaks. We apply two different PANIC-type tests. First, following Bai and Carrion-i Silvestre (2009), we consider sharp breaks under common factors. Then we apply the extended version of Nazlioglu et al. (2023) for Fourier breaks, which is the test we focus on. Table 3 lists the results obtained from both unit root tests.

First, when we analyze the results obtained from the PANIC test with sharp breaks, the null hypothesis of a unit root cannot be rejected for both cross-country and panel dimensions. In other words, the budget balance has a random process across EMs and does not tend to return to its mean. So, the fiscal structure in the EMs is not sustainable. These results are largely consistent with studies that take sharp breaks into account using various empirical methods (see. Makrydakis et al., 1999; Goyal et al., 2004; Lusinyan and Thornton, 2009; Afonso and Jalles, 2012; Apergis, 2015; Chibi et al., 2019).

Let us now look at the results of the PANIC test with smooth breaks. The findings from the PANIC with the Fourier breaks test show significant differences. Contrary to the PANIC with the sharp breaks test, the null hypothesis of a unit root is rejected for the panel statistics; in other words, the shocks are temporary. In this case, even if the budget balance deviates from its average in EMs, it returns to its average in the long run, indicating that the fiscal structure is sustainable. There is a significant increase in the evidence against stationarity in Cross-sectional results. While budget balance is not stationary for any country in PANIC with sharp breaks, this number increases to 6 countries (Indonesia, Peru, Philippines, South Africa, Thailand, and Türkiye) in PANIC with Fourier breaks. Accordingly, while an unsustainable structure is observed under sharp breaks for EM countries in general, a sustainable structure is observed under Fourier breaks. Similarly, country-specific results show that there is a structure that varies according to the type of breaks.

Table 3. Panel Unit Root Test Results

	PANIC-with Sharp Break				PANIC-with Fourier Break	
	Bai and Carrion-i-Silvestre (2009)				Nazlioglu et al. (2023)	
Countries	**MSB**	**p-val.**	**TB-1**	**TB-2**	**LM**	**p-val.**
Brazil	0.033	0.214	1998	2005	-2.412	0.776
Chile	0.056	0.816	1983	1990	-3.223	0.304
China	0.058	0.585	2002	2014	-2.416	0.774
Colombia	0.116	0.567	1999	2008	-3.390	0.231
Greece	0.061	0.874	2000	2008	-2.052	0.926
India	0.032	0.661	1980	1988	-3.641	0.147
Indonesia	0.145	0.928	1990	1997	-5.596***	0.001
Korea	0.067	0.904	1977	2000	-2.058	0.929
Mexico	0.036	0.142	1989	1999	-2.595	0.674
Peru	0.133	0.886	1977	1985	-4.129*	0.053
Philippines	0.044	0.360	1989	2001	-3.855*	0.087
South Africa	0.065	0.246	1998	2012	-4.218**	0.043
Thailand	0.033	0.199	1993	2002	-4.032*	0.065
Türkiye	0.052	0.844	1988	1998	-4.787**	0.010
Panel Results						
P	19.715	0.875			57.823***	0.001
P_m	-1.107	0.866			3.985***	0.000
Number of max. factors	4				4	

Notes: The maximum lag length is considered as 2. The t-statistic information criterion is used to determine the appropriate lag length. TB-1 and TB-2 represent the first and second break dates, respectively[7]. The maximum number of factors for PCA is determined according to the $\min\left(\sqrt{N}, \sqrt{T}\right)$. Values in square brackets are p-values. ***, **, * indicate rejection levels of 1%, 5% and 10% respectively.

The results of the analysis under the Fourier framework also include empirical evidence that fiscal sustainability is not valid. In 8 countries (Brazil, Chile, China, Colombia, Greece, India, South Korea, and Mexico), the budget balance cannot return to its previous position due to Fourier shocks. In these countries, the standard deviation of the budget balance is approximately 4% higher than in sustainable countries (see Table 2). Similarly, political stability decreased by 0.21% in countries with fiscal unsustainability, while it improved by 0.04% in other countries (1996-2022 period average, WGI, 2024). The data reveal higher

[7] So, what do the break dates tell us? When we analyze the break dates in Table 3, we see that during the period under review, many breaks emerge on a global scale. This situation leads to various changes in the budget balance that we use in the analysis. The break in 1977 was a result of the economic problems that began in the early 1970s. The stagflation environment in the early 1970s, the Vietnam War, the collapse of the Bretton Woods System, the oil embargo initiated by the Arab countries in 1973, the great famine in the Soviet Union in 1972, etc., deeply affected the economies and caused this effect to last until the end of the 1970s. The energy crisis of 1979 at the end of the 70s, the international debt crisis of the 1980s, and the financial crisis of 1987, referred to as Black Monday, structural breaks in the 1988-1990 period. The reason for the breaks between 1998 and 2002 can be considered the effects of the Asian Financial Crisis of 1997 and the disruptions in oil production in 1998-1999. In 2008, the most important reason for the break was the global financial crisis. In addition, the debt crisis in Europe during this period caused problems in many economies. In 2014 and the following period, many problems on a global scale such as the ups and downs in growth rates in emerging countries, increases in the PMI index, changes in oil and energy prices, fluctuations in inflation, increases in industrial input costs, increases in commodity prices, FED interest rate hikes, political and social problems in the Middle East caused breaks. Therefore, taking structural breaks and common factors into account is important for making correct inferences in empirical analyses.

instability in the budget balance and political arena in countries with fiscal unsustainability compared to others. Furthermore, there are significant differences in the components of the budget balance between groups of countries where fiscal sustainability is valid and where it is not. Based on the averages for the 1970 and 2022 periods, government expenditures and government debt increased by 123% and 269%, respectively, in countries with fiscal unsustainability, while these rates were 52% and 58% in countries with fiscal sustainability. Especially in Brazil, China, Greece, and India, the rapidly increasing debt ratio in recent years threatens the budget structure. Due to this difference, in countries with fiscal unsustainability on average throughout the analysis period, the share of the budget balance in GDP is 0.15% lower than in other countries (IMF, 2024b).

The results for the countries that we found to be unsustainable using the PANIC test with smooth breaks are consistent with Makrydakis et al. (1999), Afonso and Jalles (2012), Apergis (2015), and Polat and Polat (2021) for Greece; Goyal et al. (2004), for India; Campos and Cysne (2020) for Brazil, whereas they conflict with Cuestas and Regis (2018) for China and Rajakaruna and Suardi (2022) and Deheri and Nag (2023) for India. On the other hand, the results for countries where the findings favor sustainability are consistent with Marks (2004), Adrison (2024), and Rajakaruna and Suardi (2022) for Indonesia; Ghatak and Sanchez-Fung (2007), and Rajakaruna and Suardi (2022) for Thailand; Yavuz et al. (2023) for Türkiye.

6. Conclusion

The paper tests fiscal sustainability for 14 EMs with a fresh approach, accounting for common factors and Fourier breaks. It also reports the findings of the sharp-break method to measure whether the same data set responds differently to the Fourier approach. Indeed, methods that can examine a limited number of sharp breaks may be insufficient to explain the data structure in empirical analyses of EMs that are exposed to many unstable periods. The different empirical results of the two approaches support our expectations. In contrast to the sharp-break approach, the Nazlioglu et al. (2023) approach confirms fiscal sustainability, according to the empirical evidence at the panel level. Similarly, in the country-level findings, the sharp-break approach does not confirm fiscal sustainability for any EMs, while the Fourier-break approach confirms it for about 43% (Indonesia, Peru, Philippines, South Africa, Thailand, and Türkiye) of the sample of 14 EMs. Our results contribute to the literature by empirically demonstrating the importance of simultaneously considering common factors and Fourier breaks when analyzing fiscal sustainability in samples exposed to multiple shocks, such as EMs.

The Fourier panel outcomes point out that shocks in EMs do not have a permanent effect on the budget balance. In other words, sustainability is ensured if, barring exceptional factors, the past fiscal behavior of governments remains unchanged in the future (Afonso and Rault, 2010). Hence, governments should stay on the path of predictability when determining budget revenue, expenditure, and debt policies. Politicians should endeavor to avoid major changes in market behavior among producers and consumers. To ensure that fiscal sustainability remains strong in the following periods, these countries should not compromise on fiscal discipline policies, measures should be taken to address weaknesses identified in the sub-classifications of the budget balance, fiscal reserves should be increased to address national or global shocks, and develop long-term policy measures to address issues that could burden the budget balance in the future, such as demographic change, migration policies, and environmental problems.

The paper reveals that fiscal sustainability is not valid in some countries based on cross-sectional results. In these countries, structural reforms are needed in taxation, expenditure, and debt areas to ensure the sustainability of the budget structure. Governments should legislate fiscal rules, such as setting upper limits, to minimize high debt and expenditure ratios. Debt sources and government expenditures should be directed to efficient areas. While transparency and accountability mechanisms should be effectively implemented in government expenditure, election economics, and populist expenses should be avoided. On the other hand, effectively combating the informal economy to broaden the tax base, reducing inequalities in the tax system by increasing the share of direct taxes, and generating additional fiscal resources by taxing negative externalities, such as environmental taxes, will facilitate the improvement of the fiscal structure from the perspective of government revenues. Furthermore, in these countries, where instability is higher than in others, monetary and fiscal policies should be coordinated to minimize volatility in macroeconomic indicators such as inflation, unemployment, and exchange rates.

Finally, this article has certain limitations inherent to empirical analysis. This article focuses on the budget balance as the primary indicator of fiscal sustainability. Future research could re-examine fiscal sustainability using different indicators such as government debt, government expenditure, and government revenue, employing the novel empirical methodology of this study. Moreover, future research could provide a broader perspective on this area by using sub-economic and functional classifications of fiscal sustainability. The article examines 14 EMs, taking the current data as an example. Researchers can analyze various country groups. Although the study uses the maximum available data for analysis, future studies could examine longer periods if new data or databases become available.

Declaration of Research and Publication Ethics
This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement
The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest
There is no potential conflicts of interest in this study.

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Data and Codes
Available upon request from corresponding author.

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