Public finances sustainability by panel data models with cross-sectional dependence: analysis of Brazilian states

Eduardo Lima Campos, Rubens Penha Cysne

https://doi.org/10.1590/0103-6351/7588

Submitted on: 2023-06-29
Posted on: 2023-06-30 (version 1)
(YYYY-MM-DD)

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Public finances sustainability by panel data models with cross-sectional dependence: analysis of Brazilian states

Sustentabilidade das finanças públicas via modelos para dados em painel com dependência cruzada: análise dos estados brasileiros

Eduardo Lima Campos[(1,2)]
Rubens Penha Cysne[(1)]
[(1)]EPGE Brazilian School of Economics and Finance
[(2)]National School of Statistical Sciences

Abstract

This study investigates the sustainability of Brazilian states' public finances with quarterly revenue and expenses data from 2006 to 2020, aimed at the identification of groups of states that share similar patterns. The technique adopted is a panel data model that avoids mistaken inferences by controlling for cross-dependence among states. We find two clear patterns, from which we identify a fiscally sustainable group of only 9 states and an unsustainable group, comprising the remaining ones.

Keywords: Cross-dependence panel methods; fiscal sustainability; Brazilian states public debt.

JEL Codes: E52, E62, H68

Resumo

Este estudo investiga a sustentabilidade das finanças públicas dos estados brasileiros a partir de dados trimestrais de receitas e despesas entre 2006 e 2020, com o objetivo de identificar grupos de estados que apresentem características semelhantes. É utilizado um modelo para dados em painel que permite controlar a dependência cruzada entre os estados, cuja omissão poderia levar a conclusões equivocadas. Encontramos dois padrões claros, a partir dos quais identificamos um grupo fiscalmente sustentável de 9 estados e um grupo insustentável, composto pelos demais.

Palavras-chave: Métodos de painel de dependência cruzada; sustentabilidade fiscal; dívida pública dos estados brasileiros.

Códigos JEL: E52, E62, H68

1 Introduction

The COVID-19 pandemic has brought to the forefront the potential consequences of unsustainable public finances. Although many empirical works focus on the federal level, a relevant part of Brazilian public debt is related to the state level. The fiscal situation of the Brazilian states is also interesting because the Fiscal Responsibility Law sets conditions for public debt assumption, loan guarantees, budget deficits, tax waiver, and government expenses, thus motivating states' governments to maintain sound finances.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Brazil is a country of continental dimensions, comprising 26 states and one Federal District, and, regarding economic and financial issues, there is a high diversity among them. Therefore, the study of the evolution of public debt is relevant not only at the level of the consolidated public sector but also at the state level. Even if the country's public debt is unsustainable, some states may be fiscally sustainable. This prompts us to look at the specific fiscal situation of each state, in order to investigate whether it is possible to discriminate between sustainable and unsustainable groups of states.

Panel analysis allows for controlling the effect of common factors that might affect the states' fiscal variables. In the present work, we adopt a panel structure that can also incorporate terms to control for a cross-dependence among states. Had this not been done, the conventional statistical tests also might fail to identify cointegration relationships. This is a problem because the usual sustainability condition is a long-term equilibrium between revenue and expenses` series. Therefore, the omission of cross-dependence terms might lead to mistaken conclusions supporting fiscal unsustainability.

First, we estimated a general panel model, considering quarterly data of primary revenue and total expenses – in relation to the gross domestic product (GDP) of each state - from 2006 to 2020. The existence of a cross-correlation structure among the panel units was previously tested, using the cross-sectional dependence (CD) method by Pesaran (2004). Since this dependence was evidenced, at the usual significance level, we use unit root and cointegration tests that allow for controlling its effects.

Finally, we proposed a strategy to discriminate between fiscally sustainable and unsustainable subpanels of states. Suitable statistical panel tests were applied in order to analyse the quality of the identification. This strategy proved to be effective to distinguish the states and led to a sustainable group of only 9 states, while the others comprised an unsustainable group. As a practical application, these results may be an alert for the unsustainable states` governments to improve their fiscal policies.

To the best of our knowledge, no previous work either investigated the fiscal sustainability of the Brazilian states using panel techniques that incorporate (after testing) cross-dependence effects and proposed a strategy to make a clear distinction between sustainable and unsustainable groups of states.

The structure of the work is the following: Section 2 reviews the literature; Section 3 brings a brief history of the Brazilian states' indebtedness; Section 4 describes the data;

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

methodology is present in Section 5; Section 6 analyses the whole panel of Brazilian states; in Section 7, we group the states and provide results for the resulting subpanel; Section 8 discusses the results; Section 9 further verifies whether some states are weakly or strictly sustainable; Section 10 concludes.

2 Literature review

2.1 Theoretical literature

Formally, fiscal sustainability refers to a government's respect for its intertemporal budget constraint (Blanchard et al., 1990). More minutely, a government's current debt must be inferior or equivalent in size to the expected primary surpluses for the future, discounted at present value. Straightforwardly, fiscal sustainability alludes to a government's capacity of settling its debt in the long run.

One way to assess fiscal sustainability is to apply econometric techniques to the analysis of time series data. An example of such technique consists of tests on the stationarity of public debt, as demonstrated in the seminal work of Hamilton and Flavin (1985). Alternatively, cointegration analysis of expenses and revenues' time series is another example of econometric technique applied to the assessment of fiscal sustainability. Cointegration tests have been employed by several authors who have written papers on fiscal sustainability, such as Trehan and Walsh (1988), Hakkio and Rush (1991), Bohn (1991), Haug (1991), Quintos (1995), to name a few. In particular, Pastore (1994), Rocha (1997) and Issler and Lima (2000) exemplify academic works that have used these tests to analyse Brazilian context.

Nonetheless, this methodology can be enriched with panel models, which allows for controlling the effect of common factors that might affect fiscal variables (Baltagi, 2008). The disregard for the cross-section dimension makes cointegration tests to have a low power of identifying long-term relationships (Hsiao (2007), Duran-Vázquez et al. (2011)). Moreover, conventional panel tests may fail to identify long-term relationships if the dependency among units is not structurally controlled for (Guisan, 2001). On that account, neglecting either the cross-section dimension or the statistical dependence among panel units might lead to mistaken inferences concerning fiscal sustainability.

2.2 Empirical literature

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

There is a vast international and Brazilian empirical literature on fiscal sustainability. Most studies are based on two approaches: analysing the stationarity of the deficit and public debt-GDP ratio series and assessing sustainability through cointegration between government revenues and expenditures. Subsequent studies refined these analyses and incorporated more complex elements into the models.

Concerning international references, some authors have addressed sub-national fiscal sustainability. Foremny (2014) examines how fiscal rules and tax autonomy affect the local government`s deficits of European countries such as Austria, Spain and Belgium. Mitze and Matz (2015) investigate the effects of regional public debt on per capita GDP, at the level of German federal states. The research conducted by these authors points to the existence of a negative relationship between these two variables. Burret et al. (2016) applied a panel methodology to analyse German states, finding that most of them are fiscally unsustainable. Ji et al. (2016) discusses a sufficient condition for fiscal sustainability of US countries and municipalities and examines the importance of intergovernmental aid for sustainability. Akram and Rath (2020), using cointegration and dynamic ordinary least squares techniques, find evidence of strong fiscal sustainability for most of the Indian states. Li and Du (2021) measure the effects of vertical imbalance and transfer payments on the fiscal sustainability of the local governments in China, under the framework of fiscal decentralization.

Regarding the Brazilian economy, an analysis of fiscal sustainability from 1997 to 2015 was conducted by Triches and Bertussi (2017). The authors applied a multicointegration analysis with structural breaks and concluded that government debt was weakly sustainable. Another author has written about Brazilian fiscal sustainability is Luporini (2000, 2001 and 2015), who estimated impulse response functions for fiscal policy in face of shock in the debt/GDP ratio. The author concludes that, despite a certain instability in the behaviour of public debt until the 1990s, the last period analysed, ending in 2013 (thus excluding the critical years 2014/2015), evidenced a trend towards stabilization of the debt/GDP ratio, which followed a sustainable trajectory. Tavares et al. (2020) used the classically balanced budget hypothesis, with the aid of an econometric approach based on stationarity tests and cointegration of fiscal variables, covering the period from 2000 to 2017. Their results indicate that the public deficit has presented a non-stationary behaviour.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Rocha (1997) and Lima and Simonassi (2005) evaluated the dynamics and sustainability of Brazilian debt. Their conclusions were similar: the Brazilian capacity of controlling its indebtedness is deeply related to the revenues from seigniorage. The fact that this does not happen at a state level motivates subsequent studies into the fiscal sustainability of Brazilian states. Additionally, some works discuss the role of the Brazilian Federalism in determining the fiscal responsibility of the states` government - see, for example, Nunes and Nunes (2000), Mello and Slomski (2008), Linhares et al. (2013), Afonso (2016), Caldeira et al. (2016) and Tinoco (2018).

Simonassi et al. (2021) employed the fiscal reaction function (Bohn, 2008) to investigate the solvency of the investment policy carried out by subnational governments in Brazil, based on a panel model. Their results provide evidence against the sustainability of the fiscal policies in Brazilian states.

Nevertheless, some states may be fiscally sustainable, even if a panel estimation aggregating all states suggests fiscal unsustainability. In the present work, we not only investigate the fiscal sustainability of a panel comprising all Brazilian states but also identify and distinguish groups of sustainable and unsustainable states. Additionally, we test and incorporate cross-dependence terms to the panel modelling and apply sustainability tests especially developed to deal with their effects, thus avoiding mistaken inferences.

3 A brief history of the Brazilian states' indebtedness

The debt crisis of the Brazilian states starts, according to Silva and Sousa (2002), after the Mexican foreign debt moratorium in 1982, marked by a reduction in the inflow of foreign capital. The states failed to honour their external debts, forcing the Federal Government to pay them (the National Treasury was the guarantor of these operations). The following recurrent renegotiations of state debts showed the unwillingness of the Brazilian states to conduct responsible fiscal policies, which resulted in further increase in debt levels (Mello and Slomski (2009), Almeida (1996), Rigolon and Giambiagi (1999) and Serra and Afonso (2007)).

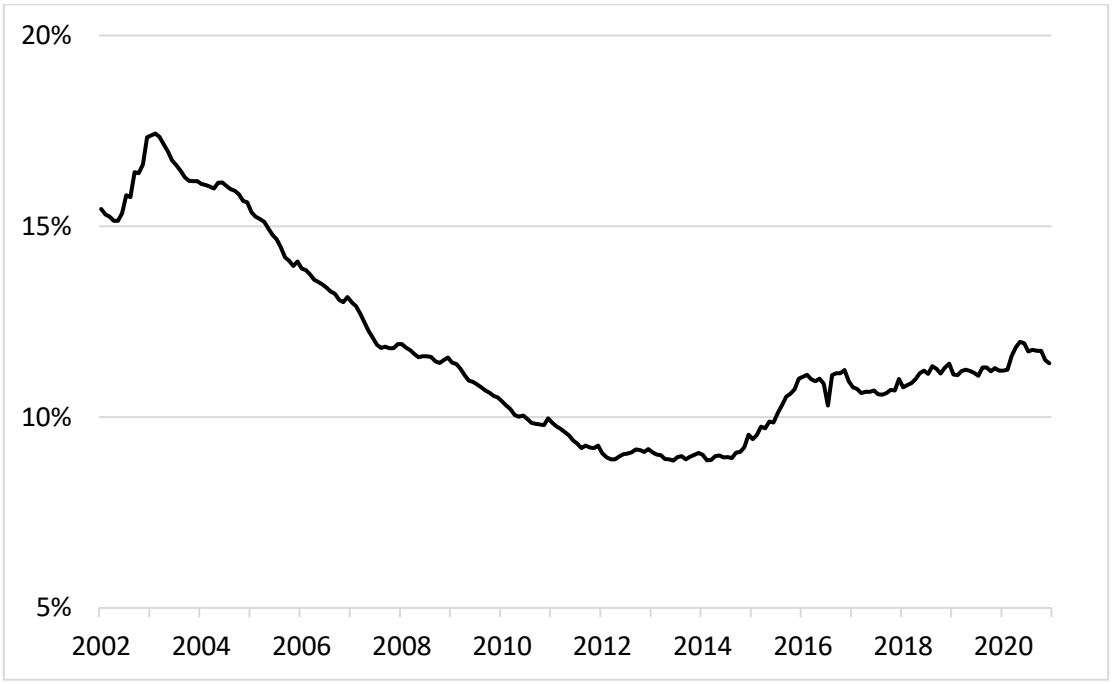
According to Arena and Revilla (2009), the country underwent a strong process of fiscal adjustment in the 1990s, characterized by drastic increases in tax revenues and cuts in infrastructure spending as a way to finance increases in current spending. These authors also stated that Brazil's fiscal situation improved significantly after the Real plan.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

This improvement was the result of fiscal reforms (Fernandes and Santana, 2018). For Serra and Afonso (2007) these measures included changes to subnational debt renegotiation schemes, reform of the state tax on the circulation of goods and services (ICMS) (in the so-called Kandir Law), and the creation of the fiscal responsibility law, among others.

The recent evolution of the fiscal situation of the Brazilian states can be divided into two phases. The first phase started in 1997 when the states and the Union reached an agreement and lasted until mid-2007. According to Santos (2010), the improvement in state indebtedness indicators that occurred from the 2000s onwards can be attributed to the requirements of the Fiscal Responsibility Law and debt renegotiations (Guardia and Sonder (2004) and Serra and Afonso (2007)). The states began to comply with rules for more responsible fiscal management. Moreover, the favourable economic circumstances and the restrictions on access to credit contributed to an increase in revenue and limited the growth of expenses (Tinoco, 2018). Figure 1 shows that the state net debt reached 17.45% of the GDP in 2003 and declined thereafter, reaching 9% of the GDP in 2012.

Figure 1 - Public sector net debt (% gdp) - state governments



Source: Central Bank of Brazil

The second phase of the debt crisis started in 2008, triggered by the global financial crisis. It was characterized by a gradual reduction in revenue, an increase in expenses (mainly in personnel expenses) and a reduction in the primary result. At the same time, the Federal

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Government eased credit restrictions on states, contributing to the worsening of fiscal indicators. Consequently, there was a great increase in new bank and foreign loans, causing the debt of the federal units to rise again (Tinoco, 2018). Table 1 shows the successive negative nominal balance of states.

Table 1 - Nominal balance, primary balance and nominal interest of states

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
(% GDP)											
Nominal Balance	-2.4	-1.7	-1.8	-2.9	-1.3	-1.4	-0.2	-0.6	-0.4	-1.0	0.1
Primary Balance	0.1	0.4	0.6	0.6	0.7	0.8	0.8	0.7	1.0	0.8	0.5
Nominal interest	2.5	2.1	2.3	3.5	2.0	2.2	1.0	1.3	1.3	1.8	0.4
(R$ Billion)											
Nominal Balance	-26.1	-20.0	-23.1	-43.8	-22.9	-27.5	-4.8	-13.7	-10.3	-29.7	3.3
Primary Balance	1.6	4.6	7.2	8.6	11.9	16.1	17.2	16.4	26.0	25.9	18.0
Nominal interest	27.7	24.5	30.3	52.4	34.9	43.6	21.9	30.1	36.3	55.6	14.6

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
(% GDP)											
Nominal Balance	-1.0	-0.3	-0.7	-0.7	-1.0	-1.2	-1.1	-0.7	-0.8	-0.4	0.0
Primary Balance	0.4	0.7	0.4	0.2	-0.2	0.2	0.1	0.1	0.1	0.2	0.5
Nominal interest	1.5	1.0	1.1	0.9	0.8	1.4	1.2	0.8	0.8	0.6	0.5
(R$ Billion)											
Nominal Balance	-40.4	-14.0	-34.3	-36.6	-59.7	-73.3	-67.4	-42.6	-52.9	-30.3	3.2
Primary Balance	17.0	29.6	18.8	13.0	-13.2	9.1	6.8	6.9	4.7	16.2	38.3
Nominal interest	57.4	43.7	53.1	49.5	46.5	82.3	74.2	49.5	57.7	46.6	35.0

Note: The primary balance is the difference between government revenues and expenses (without nominal interest). Nominal balance is the difference between primary balance and nominal interest. Source: Central Bank of Brazil (BCB).

Nunes et al. (2019) highlighted that several institutional changes have been observed due to the interpretation of the norms provided for in the legislation of the Fiscal Responsibility Law by the Courts of Accounts (TCEs). Although this does not generate any compliance issue for governors and mayors, since they comply with the rules of the Courts of Accounts, it can make financial management unfeasible, and certainly reduce the uniformity of fiscal regulation in the Federation. Therefore, this fact has contributed to the reduction of the fiscal rule's ability to control the excessive spending and over-indebtedness of governments.

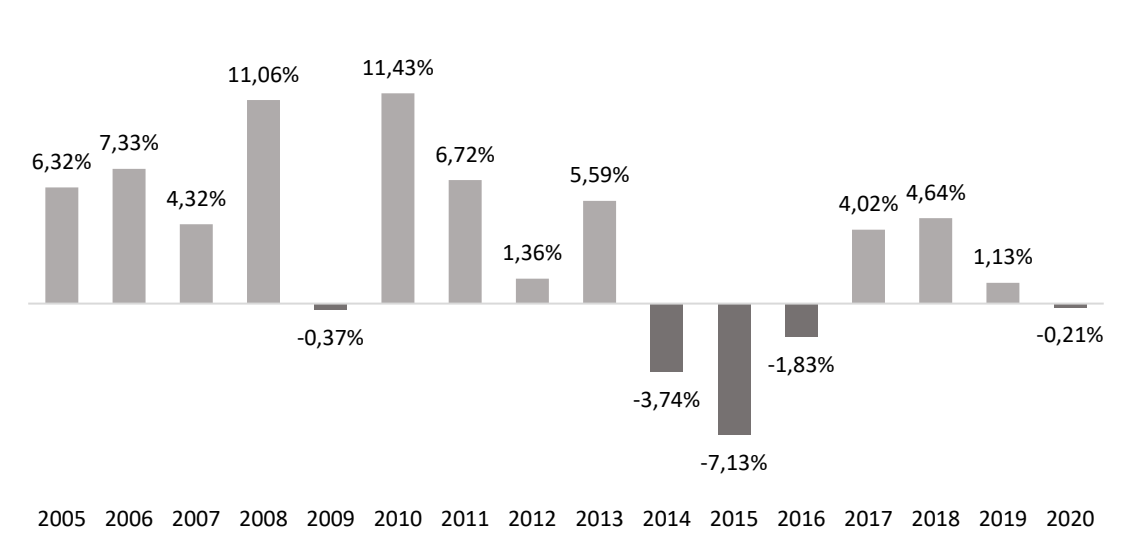
More recently, revenue has been greatly affected by the economic slowdown and the 2015-2016 recession. The economic contraction took a toll on investment expenses, which suffered a sharp reduction. Nevertheless, even with this adjustment, many states faced difficulties to honour commitments (in some cases interrupting public services and delaying the payment of salaries and pensions). That led to another debt renegotiation between states and the Federal Government, materialized by Complementary Laws (LC) 148/2014 and 156/2016, which changed the financial charges of the 1997 renegotiations, generating a discount of around R$ 38 billion in the debts of the states to the Union and

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

extended the debt for another twenty years, also offering a grace period in the payment of interest and principal. This change in the debt correction would give sub nationals fiscal leeway for investments, probably through more indebtedness. This effect is amplified when one considers the possibility of correction retroactivity (Monteiro, 2015). In addition, the Fiscal Recovery Regime (RRF) was created in 2017, with the aim of easing the finances of the states that were in dire situations.

The main fiscal consequence of the COVID-19 pandemic in 2020 for the States was the drop in tax collection due to the reduction in the level of economic activity. Figure 2 shows the drop in 2020 of the main state tax, the ICMS (state value-added tax on the circulation of goods, interstate and intercity transportation and communication services). Additionally, there was increased pressure on expenses to face the pandemic.

Figure 2 - Real growth rate of ICMS



Source: The Brazilian public sector accounting and fiscal information system (Siconfi).

On the other hand, some factors helped to partially recover state revenue, such as emergency aid, a temporary suspension of debt payments and the direct transfer of resources from the Union to the states, with a straight impact on the states' primary results.

First, with the drop in the IPI (Tax on Industrialized Products) and Income Tax collections, the State Participation Fund[1] was reduced, generating a smaller transfer to the

[1] A mechanism for transferring funds from the Union to the states and the Federal District in order to equalize the fiscal capacity of the federative units.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

states at a time when spending increased due to the need to face the pandemic. However, the Federal Government, through the Federative Program to face the COVID-19 pandemic (Complementary Law (LC) No. 173/2020) and provisional measure (MP) No. 938/2020, made a financial transfer to the states, aimed at mitigating the contraction of the State Participation Fund and the reduction in tax collection.

Moreover, the expenses of the states increased by 2,2% in 2020[2], mainly related to the social security and assistance, health area, and sanitary issues to contain the spread of the coronavirus (together, the expenses of these areas increased by 8,3% in 2020[3]). Due to this pressure on expenses, the Federal Government carried out another transfer which instituted financial aid to the states, together with the suspension of payment of state debt instalments, to minimize the impact of the pandemic, which affected mainly the primary result and the indebtedness of the federative units (Pellegrini, 2020).

4 Data

The primary revenue of the states was computed by adding the tax revenue to current transfers. The proxy of total expenses (sum of primary expenses and nominal interest) was calculated from the difference between the nominal balance and the primary revenue. The nominal balance followed the “below the line” criterion, resulting from the variation of the net debt stock[4]. This dataset is available on a bimonthly basis. We convert this data to quarterly frequency so that the entire database has the same frequency. The data was extracted from the Brazilian Public Sector Accounting and Tax Information System (Siconfi).

The state-level GDP[5] is available on a quarterly basis only for the following cases: Paraná, Ceará, São Paulo, Rio Grande do Sul, Espírito Santo, Pernambuco, Goiás, Amazonas, Federal District and Minas Gerais. The GDP of other Brazilian states are only available on an annual basis. To convert annual data to quarterly, we apply a temporal

[2] Committed expenses, except intra-budgetary and special charges. Change compared to 2019, in real terms.
[3] Corresponds to health, social security and social assistance functions.
[4] Another possibility would be to use the "above the line" criterion, by which the nominal balance is calculated from the difference between expenses and revenue, considering a proxy for the total expenses.
[5] Sources: https://www.ipardes.pr.gov.br/Pagina/PIB-Trimestral-do-Parana, https://www.ipece.ce.gov.br/pib-trimestral/, https://pib.seade.gov.br/trimestral/, https://www.ipece.ce.gov.br/pib-trimestral/, https://pib.seade.gov.br/trimestral/, https://dee.rs.gov.br/pib-trimestral, http://www.ijsn.es.gov.br/artigos/6218-pib-trimestral-1-trimestre-de-2022, http://www.condepefidem.pe.gov.br/web/condepe-fidem/pibtrimestral, https://www.imb.go.gov.br/index.php?option=com_content&view=category&id=38&Itemid=191, http://www.sedecti.am.gov.br/indicadores-mapa/, https://www.codeplan.df.gov.br/produto-interno-bruto-do-df-pib/, http://fjp.mg.gov.br/produto-interno-bruto-pib-de-minas-gerais/

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

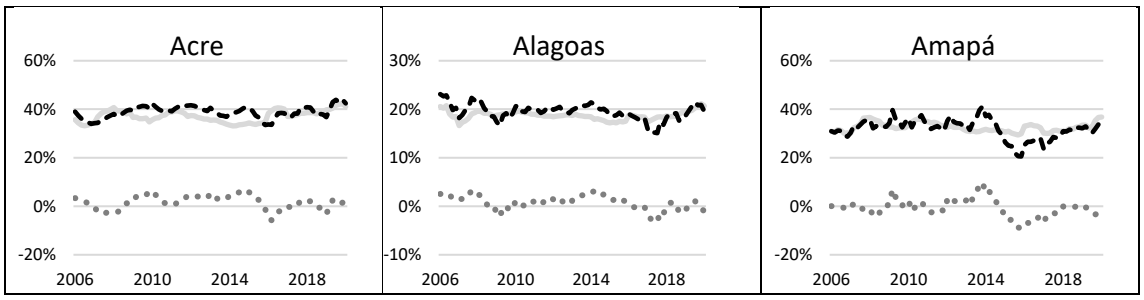
disaggregation method (Chow and Lin, 1971). The Chow-Lin technique of temporal disaggregation uses indicators with high frequency data to derive low frequency data. The high-frequency indicators are time series related to the target time series and contain its short-term dynamics. Other methods of temporal disaggregation are the Chow-Lin Method Using Dynamic Models (Santos Silva & Cardoso, 2001), the Business Cycle approach (Mönch & Uhlig, 2005) and the State-Space approach (Issler & Notini, 2016).

We based on Issler & Notini (2016) to select the set of four variables related to the economic activity of the states[6]: retail sales, energy consumption, tax collection (ICMS) and number of admissions.

The data set includes the proxy for nominal expenses and quarterly primary revenue for each Brazilian state, corresponding to the period 2006-2020. The variables are measured in relation to the GDP of each state, as usual in studies on fiscal sustainability, thus considering fiscal performance relative to economic development and making it possible a direct interpretation and comparison between the series (Afonso et al., 2005; Kirchgässner and Prohl, 2008).

Figure 3 presents graphs showing the evolution of expenses, revenue and the nominal deficit - all measured in relation to the GDP of each state - for the 26 Brazilian states and the Federal District, over the study period. From this point on, we will consider the Federal District as a state, totalizing 27 states. The pattern of evolution of revenue, expenses and nominal balance differs among Brazilian states, as we can see in Figure 3[7].

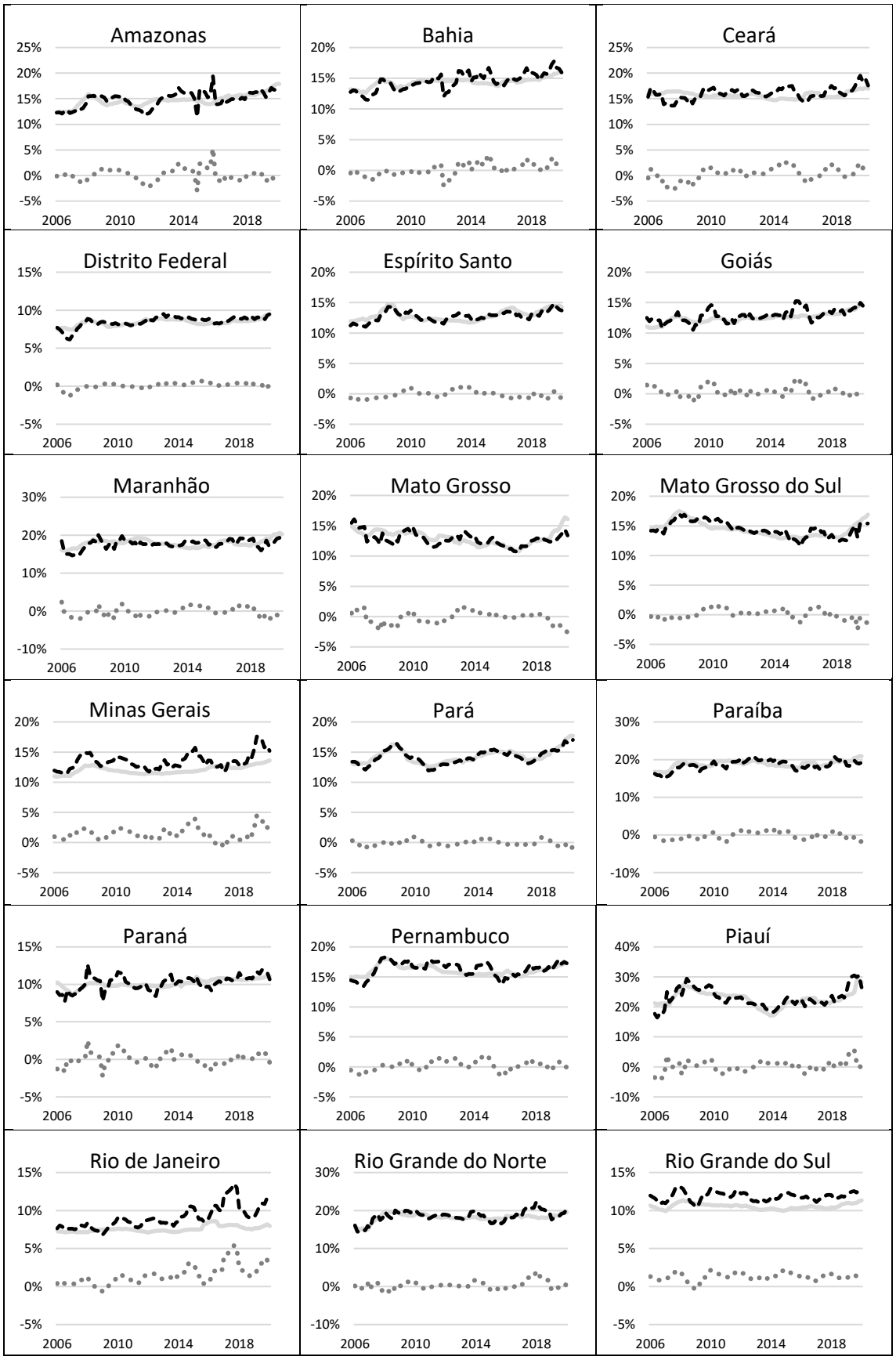
Figure 3 - Total expenses, revenue and nominal balance (% gdp) for all Brazilian states



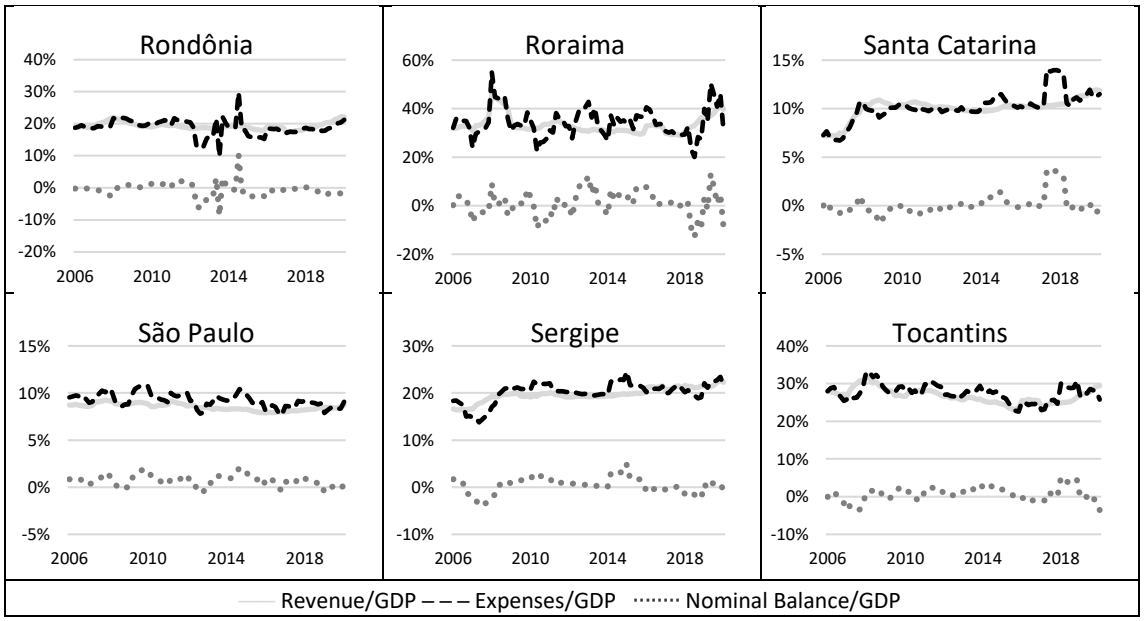
[6] Sources: Brazilian Institute of Geography and Statistics (IBGE), Power Research Company (EPE), Tax Information System (Siconfi), General Register of Employed and Unemployed (CAGED). The data were accumulated in 12 months to smooth out quarterly variations.

[7] Some descriptive statistics are available at https://www.dropbox.com/s/xkg0ogkveheg5x7/Descriptive%20statistics%20of%20each%20state.pdf?dl=0

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.



Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.



Source: Own elaboration based on data from Siconfi https://siconfi.tesouro.gov.br/siconfi/index.jsf

At the beginning of the sample period (2006-2008), we observed a slight increase in revenue of the states, which remained stable from 2009 to 2017, growing back in the following period, especially in 2019, due to the increase in tax collection. Expenses were clearly more volatile than revenue and exhibited a mildly upward trajectory in most states from 2015 to 2019. Finally, some states had deficits in a large part of the study period, like Acre, Minas Gerais, Rio de Janeiro, Rio Grande do Sul and São Paulo, while other states showed a balance between revenue and expenses, like Espírito Santo, Federal District and Pará.

5 Methodology

We investigate the fiscal sustainability of the Brazilian states by analysing the whole panel of 27 states and two subgroups based on state-specific sustainability tests. For each case, the sequence of steps presented in subsections 5.1 to 5.4 is applied.

5.1 Cross-Dependence (CD) Test

According to Pesaran (2004), conventional stationarity tests for panels tend to reject the null hypothesis of unit root if the series in the panel are dependent. Therefore, for the panel and subpanels, we start by testing for cross-sectional dependence (CD). If there is evidence of dependence, we apply tests that incorporate this dependence, thus leading to correct results. The CD test is based on the average of pairwise correlation coefficients of

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

OLS residuals from individual regressions, i.e., for each panel member (Pesaran, 2015; Baltagi, 2013).

5.2 Cross-sectionally augmented Dickey-Fuller (CADF) Panel Unit Root Test

If the CD test provides evidence to support cross-dependence, we employ the appropriate panel unit root test, developed by Pesaran (2007). The test is based on the individual ADF t-statistics averages of each unit in the panel. It eliminates cross-dependence by augmenting the ADF regression with two components: (i) the lagged cross-sectional average and (ii) the first differences from the individual series (CADF statistics), in order to capture the cross-dependence with a single-factor model. It is important to state that the test is sensitive to the number of lags. Therefore, we selected the ideal lag individually for each state based on the Akaike Information Criterion (AIC). If there is evidence that all series are non-stationary, we proceed with panel cointegration tests on expenses and revenue.

5.3 Cointegration Test for Cross-Dependent Series

A linear combination of expenses and income in the panel can be verified through panel cointegration tests. Cointegration means a significant long-term relation between expenses and revenue. In this case, we conclude that the states in the panel are fiscally sustainable (Bohn (2008); Burret et al. (2016); Larin e Süssmuth (2014)).

As with unit root tests, conventional cointegration tests are not reliable when applied to a time series panel that are cross-dependent, with a propensity to incorrectly reject the cointegration hypothesis (Guisan, 2001). Thus, here again, if the null hypothesis of the CD test is rejected, the appropriate procedure for testing cointegration is based on the error correction model for panels proposed by Westerlund (2007). This test assumes the following data generating process:

$$\Delta y_{it} = \delta_i' d_t + \alpha_i y_{i,t-1} - \alpha_i \beta_i' x_{i,t-1} + \sum_{j=1}^{p_i} \alpha_{ij} \Delta y_{i,t-j} + \sum_{j=-q_i}^{p_j} \gamma_{ij} \Delta x_{i,t-j} + e_{it}, \quad (1)$$

where $t = 1, \ldots, T$ and $i = 1, \ldots, N$ index the time-series and cross-section units respectively, and d_t include a constant and/or a linear trend (deterministic components).

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

The parameter α_i is the speed of the return to the equilibrium relationship $y_{i,t-1} - \beta_i' x_{i,t-1}$ after an unexpected shock. Hence, the null hypothesis of no cointegration is $H_0: \alpha_i = 0$ for all i. The alternative hypothesis depends on the assumptions about α_i, resulting in a pair of group-mean G-tests and another pair of panel P-tests.

The G-tests do not require the $\alpha_i s$ to be equal, which means that H_0 is tested versus $H_1^g: \alpha_i < 0$ for at least one i. Rejecting H_0 evidences cointegration for at least one of the cross-sectional units (states). The group-mean statistics are:

$$G_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \quad , \quad G_\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)} \tag{2}$$

where $SE(\hat{\alpha}_i)$ is the conventional standard error of $\hat{\alpha}_i$; $\hat{\alpha}_i(1) = \hat{\omega}_{ui}/\hat{\omega}_{yi}$, from which $\hat{\omega}_{ui}$ and $\hat{\omega}_{yi}$ are the usual Newey and West (1994) long-run variance estimators based on $\hat{u}_{it}$ and Δy_{it}, respectively, where $\hat{u}_{it} = \sum_{j=-q_i}^{p_i} \hat{\gamma}_{ij} \Delta x_{i,t-j} + \hat{e}_{it}$.

The second pair of tests, called panel tests, are based on pooling the information regarding the error correction along the cross-sectional dimension of the panel. They assume that, under H_0, $\alpha_i = 0$ for all i. This hypothesis is tested against $H_1: \alpha_i < 0$ for all i. The rejection of H_0 indicates panel cointegration. The statistics are (Westerlund, 2007):

$$P_\tau = \frac{\hat{\alpha}}{SE(\hat{\alpha})} \quad , \quad P_\alpha = T\hat{\alpha} \tag{3}$$

In order to avoid a misleading inference in case of cross-dependence among series (as alerted by Persyn and Westerlund, 2008), we bootstrapped robust critical values for the test statistics with 800 replications for each subpanel. Moreover, we used the optimal lag for each state and tested for the inclusion of a deterministic trend in each cointegration equation, since both aspects affect the results.

5.4 Common Correlated Effects Mean Group (CCE-MG) and a Test for Cointegration Coefficients

We estimate the magnitude of the cross-section β coefficient in the cointegration relationship of each panel using Common Correlated Effects Mean Group (CCE-MG) and the Cross Correlated Effects (CCE) to further explore the sustainability condition.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

These tests developed by Pesaran (2006) allow for cross-sectional dependence and incorporate unobserved common factors with heterogeneous impact.

Following Afonso and Rault (2015), we added two terms in the usual cointegration regression: the cross-section means of the revenue Rev_{it} and expenses Exp_{it} of each state i at time t. The estimated equation for each state i becomes:

$$Rev_{it} = \alpha_i + \beta_i Exp_{it} + \mu_1 \overline{Rev}_t + \mu_2 \overline{Exp}_t + \mu_{it} \quad (4)$$

where α_i is a constant specific for each state and $\overline{Rev}_t$ and $\overline{Exp}_t$ are the cross-section means.

Thereafter, following Pesaran (2006), the estimated coefficients $\hat{\beta}_i$ are averaged across panel units[8]. In case of sustainability, we tested the null hypothesis H_0: $\beta_i = 1$, against H_1: $\beta_i < 1$, and employ a classification proposed by Quintos (1995): strict sustainability if β_i is equal to one, meaning that a one percentage point increase in expenses corresponds to the same increase in revenue, and weak sustainability if β_i smaller than 1. If weak sustainability is evidenced, it means that the revenue, although react to growing expenses, do not increase at the same rate, thus alerting for unsustainability.

The CCE-MG approach is robust to the presence of common factors, for example, local spillover effects or global shocks, such as a global financial crisis (Chudik et al., 2011; Kapetanios et al., 2011).

6 Results for the whole panel

We analyse all the 27 Brazilian states, here called "the whole panel". For each state, we consider the time series of revenue and expenses[9].

First, it is necessary to assess whether the cross-section independence assumption of the conventional panel tests is valid. Therefore, we start by testing for cross-section dependence with the CD test (Pesaran, 2004). Table 2 indicates that the null hypothesis of cross-section independence is rejected at the usual significance levels (p-values near zero) for both series.

[8] For CCE-MG, β and its standard error are obtained as $\hat{\beta}_{CCE-MG} = \sum_{i=1}^{N} \hat{\beta}_{i-CCE}/N$ and $SE(\hat{\beta}_{CCE-MG}) = \sum_{i=1}^{N} \sigma(\hat{\beta}_{i-CCE})/\sqrt{N}$ for N cross-sectional units, where $\hat{\beta}_{i-CCE}$ and $\sigma(\hat{\beta}_{i-CCE})$ denote respectively the estimated individual unit time-series coefficients and their standard deviations.

[9] Some descriptive statistics are available from https://www.dropbox.com/s/g28yselx58b4f9n/Descriptive%20Statistics%20of%20the%20Whole%20Panel.pdf?dl=0

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Table 2 - Pre-Estimation Test on Cross-Section Correlation (CD Test) for the Whole Panel

		CD test	p-value	Average correlation coefficient	Absolute correlation coefficient
Brazil (Whole Panel)	Revenue	65.15	0.00	0.411	0.459
	Expenses	33.98	0.00	0.218	0.287

As cross-section dependence was evidenced, we applied the CADF panel unit root test. The results are shown in Table 3.

Table 3 - CADF Panel Unit Root Test for the whole panel

		Levels constant (no trend)		Levels constant + trend		First differences constant (no trend)		First differences constant + trend	
		Z[t-bar]	p-value	Z[t-bar]	p-value	Z[t-bar]	p-value	Z[t-bar]	p-value
Brazil (Whole Panel)	Revenue	-1.636	0.053	1.117	0.874	-9.791	0.000	-9.113	0.000
	Expenses	-1.335	0.088	-1.497	0.069	-11.652	0.000	-10.036	0.000

Table 3 indicates that the null hypothesis of unit root is not rejected for both series, at 0.05 significance level. Since the null hypothesis of the test is the presence of unit root, the results suggest that both series are nonstationary in levels, but stationary in first differences (either with or without trend)[10].

The following step is testing if the revenue and expenses series share a panel long-run relation. We apply the error correction based cointegration test for panels (Westerlund, 2007), described in Subsection 5.3, adding dummies for fiscal crisis[11] from 2014-2015 and COVID-19 crisis from 2020[12]. The results for the P_t, P_a, G_t and G_a tests are in Table 4[13].

Table 4 - Westerlund Cointegration Tests for the whole panel

	Value	Z-value	p-value	Robust p-value
Gt	-9.145	-2.319	0.033	0.019
Ga	-8.575	-1.469	0.085	0.057
Pt	-3.019	0.792	0.779	0.672
Pa	-2.370	-1.190	0.281	0.256

The results of the P_t and P_a tests indicate that the null hypothesis of no cointegration is not rejected at the usual levels, for both series, either by the simple or the robust p-values[14]. On the other hand, the G_t and G_a tests lead to the rejection of the null hypothesis at the 0.05 and 0.1 level, respectively, either considering simple or robust p-values.

These results provide evidence that, although the panel is not cointegrated as a whole, there may be at least a subgroup of states for which expenses and revenues are

[10] Univariate time series properties also indicate that all revenue and expenses series are non-stationary (see Table A.1).
[11] The 2008 global crisis did not affect the fiscal accounts of Brazilian states as much as the 2014-2015 crisis.
[12] The results without dummies were similar (see results in Table A.2).
[13] The trend component was not significant in all equations, therefore we only considered the "no trend" specification.
[14] Since we found no cointegration for the whole panel, we refrain from estimating the magnitude of the β cointegration coefficient.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

cointegrated, thus satisfying the sustainability condition. This finding motivates the remaining analysis of this work. In the next Section, we identify subpanels with similar fiscal patterns, in order to clearly discriminate a group of states that are fiscally sustainable from those that are fiscally unsustainable.

7 Results for subpanels

Since the cointegration hypothesis was evidenced for at least one subgroup of states (as indicated by the G-tests in Table 4), we proceed with the identification of these subpanels, by grouping states whose revenue and expenses share similar time series patterns. The subscript s will be used to denote a subpanel. The resulting groups are (details in Table A.1):

Subpanel 1 (no cointegration between revenue and expenses): Amazonas, Bahia, Ceará, Goiás, Maranhão, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraíba, Pernambuco, Rio de Janeiro, Rio Grande do Sul, Rondônia, Roraima, Santa Catarina, São Paulo, Sergipe and Tocantins.

Subpanel 2 (cointegration): Acre, Alagoas Amapá, Espírito Santo, Federal District, Pará, Paraná, Piauí and Rio Grande do Norte. Here, we also found evidence for β_i^s<1, meaning weak sustainability.

The descriptive statistics for each subpanel are in Table 5.

Table 5 - Descriptive Statistics for subpanels 1 and 2

	Revenue/GDP					Expenses /GDP				
Subpanel	Mean	Standard Deviation	Median	Max	Min	Mean	Standard Deviation	Median	Max	Min
1	15.86%	0.0632	14.75%	45.77%	7.11%	16.27%	0.0647	14.98%	54.94%	6.71%
2	19.41%	0.0941	17.94%	42.36%	7.45%	19.71%	0.0977	18.13%	43.92%	6.13%

The results of the CD test for cross-dependence are in Table 6.

Table 6 - Pre-Estimation Test on Cross-Section Correlation (CD Test) for subpanels 1 and 2

Subpanel		CD test	p-value	Average correlation coefficient	Absolute correlation coefficient
1	Revenue	45.68	0.000	0.452	0.491
	Expenses	25.75	0.000	0.255	0.325
2	Revenue	29.82	0.000	0.436	0.470
	Expenses	16.40	0.000	0.240	0.304

Table 6 results indicate that the null hypothesis of cross-section independence is strongly rejected at the usual levels, for both series. As expected, the result is statistically stronger

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

than those of the Table 2, since, in the present section, we defined groups based on similarities in states' time series' properties.

The results of the CADF test are reported in Table 7.

Table 7 - CADF Panel Unit Root Test for subpanels 1 and 2

		Levels constant (no trend)		Levels constant + trend		First differences constant (no trend)		First differences constant + trend	
Subpanel		Z[t-bar]	p-value	Z[t-bar]	p-value	Z[t-bar]	p-value	Z[t-bar]	p-value
1	Revenue	-0.633	0.263	-0.214	0.415	-9.168	0.000	-9.788	0.000
	Expenses	-1.374	0.075	-1.733	0.082	-9.534	0.000	-6.901	0.000
2	Revenue	-1.055	0.146	-1.107	0.134	-6.018	0.000	-8.519	0.000
	Expenses	-1.279	0.100	- 2.333	0.990	-9.125	0.000	-6.371	0.000

The results from Table 7 lead to the non-rejection of the null hypothesis, thus indicating non-stationarity, for both subpanels (but only at the 0,05 level for expenses in subpanel 1).

Since both subpanels are non-stationary, we proceed with the cointegration analysis. Table 8 shows the results of the Westerlund panel cointegration tests for subpanel 1.

Table 8 - Westerlund Panel Cointegration Tests for subpanel 1

	Value	Z-value	p-value	Robust p-value
Gt	-2.185	-1.668	0.031	0.045
Ga	-9.192	-1.552	0.014	0.020
Pt	-5.286	-0.713	0.238	0.460
Pa	-5.895	-1.185	0.118	0.260

From Table 8, we have that the null hypothesis in P-tests is not rejected for this subpanel. It corroborates with the fiscal characteristics of the states in this subpanel, when analysed individually, which did not present cointegration between revenue and expenses. However, the G-tests still suggest that some sub-groups of states, when jointly analysed, may satisfy the sustainability condition. This is additional evidence for the lack of power of the usual individual cointegration tests, as they neither consider the cross-section dimension nor explicitly control the cross-dependence structure among panel units, thus leading to spurious inferences (Hsiao, 2007). Therefore, it is not surprising that some results in Table A.1 may be misleading, possibly hiding existing equilibrium panel-relationships.

Table 9 shows the results of the Westerlund panel cointegration tests for subpanel 2.

Table 9 - Westerlund Panel Cointegration Tests for subpanel 2

	Value	Z-value	p-value	Robust p-value
Gt	-4.119	-2.668	0.063	0.039
Ga	-9.192	-2.552	0.054	0.027

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Pt	-7.066	-2.151	0.026	0.017
Pa	-13.070	-3.645	0.014	0.005

It follows that the subpanel 2 satisfies the sustainability condition. The null hypothesis is rejected for both panel tests (P_t and P_a), indicating that the revenue and expenses in this subpanel are cointegrated. The G-tests reinforce that no state (or subgroup of states) in subpanel 2 may be classified as fiscal unsustainable. We conclude that this subpanel is clearly sustainable, either individually or grouped.

The results without dummies were similar (see Table A.2). The only change was the result of the G_t test in Table 8 from robust p-value, which becomes non-significant at the 0.05 level (but remains at the 0,1 level). Note that incorporating the dummies only reinforced the general conclusions.

8 Discussion

The results for the whole panel, in Section 6, are in accordance with recent works as Tavares, 2020; Simonassi et al., 2021, which find, from aggregated data, that Brazilian fiscal policy may be unsustainable.

As for the results of Section 7, we observe that the group of fiscally sustainable states (subpanel 2) corroborates, for example, Pellegrini (2020), who classified Espírito Santo, Pará, Alagoas, Acre and Paraná as fiscally responsible states. On the other side, Tinoco (2018) warned about the worrying fiscal situations in Rio de Janeiro, Rio Grande do Sul and Minas Gerais, mainly because of their high cost of personnel. Indeed, these states were classified in the “unsustainable” subpanel 1.

Additionally, when considering the economic differences among Brazilian states, it can be observed that some public administrations present a more challenging scenario than others. States such as Rio de Janeiro and Rio Grande do Sul, for example, were forced to make significant fiscal adjustments to regain the ability to pay salaries on time, while other states, such as Espírito Santo and Paraná, for example, after some previous reforms, had a more comfortable fiscal situation (Giambiagi et al., 2021).

Despite the differences among the states, most of them share at least two characteristics. The first one is the high weight of personnel expenses in state revenues and total primary expenses. The Fiscal Responsibility Law established a fiscal rule in which the personnel expenses of the states cannot exceed 60% of the net current revenue of the entity.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

According to a report by the National Treasury[15], six states were above this limit in 2020, and another six had a commitment of more than 55%. The median ratio of these personnel expenditures to total primary expenditures was 54% in 2020. This shows how rigid these states' budgets are, since states' governments are also responsible for current expenses necessary to carry out many public policies, thus leaving little space for investment.

The second common characteristic among some states refers to the collection capacity. The ICMS is the main tax levied by the states and, therefore, the main source of revenue for the states. However, the ICMS tax base has been emptied over the decades by factors such as changes in the economic structure of the country and the increase in tax expenditures, the latter mainly as a result of the so called "tax war" (Nascimento, 2008; Afonso et al., 2017; and Afonso et al., 2018).

Additionally, the expansion of credit operations from 2010 onwards also contributed to the fragility of the public accounts of several state entities. Many states conducted credit operations with the Federal Government's guarantee. In this period, even those entities that did not meet the criteria for obtaining Federal guarantees were reached by means of an exceptional rule (Pinto et al., 2014). All these factors have contributed, to a greater or lesser extent, to the sustainability of the states' debt. Thus, the fiscal situation of these states has become quite serious in recent years, characterized by an increase in debt and mainly by a significant deterioration in nominal results. Although the main problem is structural, the strong economic recession from the second quarter of 2014 to the fourth quarter of 2016 (CODACE, 2020) and the COVID-19 pandemic also contributed to aggravate the fiscal problems.

Finally, it should be observed that some international references reach different conclusions concerning fiscal sustainability at the panel units` level. For example, Burret et al (2016) also identifies two groups of German states, providing evidence that most of them are unsustainable while a smaller group is weakly sustainable, exactly as we found for Brazilian states. Li and Du (2021) find that the fiscal behavior of local governments in China is unsustainable. On the other hand, Akram and Rath (2020), using state-level data from India, found strong fiscal sustainability for most states.

9 Strict or weak sustainability?

[15] Available in: https://www.tesourotransparente.gov.br/publicacoes/boletim-de-financas-dos-entes-subnacionais/2021/114.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Since empirical evidence suggests that expenses and revenue are cointegrated in the subpanel 2, we further explore the sustainability condition, by estimating the cross-section coefficient in the cointegration relation of each panel using the Cross Correlated Effects (CEE) and the Common Correlated Effects Mean Group (CCE-MG) estimation procedures developed by Pesaran (2006), as described in the Subsection 5.4 (since there is no cointegration for subpanel 1, we refrain from reporting their estimates).

Here, we rewrite equation (4) in Subsection 5.4, for convenience: $Rev_{it} = \alpha_i + \beta_i Exp_{it} + \mu_1 \overline{Rev_t} + \mu_2 \overline{Exp_t} + \mu_{it}$, where α_i, a constant, Rev_{it} and Exp_{it}, revenue and expenses in state i at time t, respectively, while $\overline{Rev_t}$ and $\overline{Exp_t}$ denote the cross-section averages of revenue in time t. The results of equation (4) are presented below[16] (standard errors in parentheses):

$$Rev_{it} = \underset{(0.0158)}{-0.003} + \underset{(0,0737)}{0.389 Exp} + \underset{(0,2984)}{0.952 \overline{Rev_t}} - \underset{(0,1289)}{0.295 \overline{Exp_t}} \quad (5)$$

The results indicate a panel-cointegration coefficient of 0.389, thus providing evidence against H_0: $\beta_i^s = 1$ (strict sustainability) in favor of H_1: $\beta_i^s < 1$ (weak sustainability). It means that, for the states in this subpanel, the revenue does not increase at the same rate as expenses. Individual cross-section β_i coefficients and the respective statistics are reported in Table A.3 and varies from 0.112 to 0.854, showing that the long-run relation is also smaller than one in all cross-sections. These results provide additional evidence of a shared weak fiscal sustainability for the states within the subpanel 2.

10 Conclusions

This work investigated the sustainability of the Brazilian states' public finances. We applied panel methods that incorporate the cross-dependence among the units (states), thus increasing the power of the conventional time-series tests and avoiding mistaken conclusions indicating fiscal unsustainability. The suitability of this approach stems from the many shared economic and financial features of Brazilian states, as these might lead to wrong results from econometric assessments without cross-dependence control.

The CD test proposed by Pesaran (2004) provided strong evidence for cross-dependence among Brazilian states. Therefore, we use specific sustainability tests that allow for controlling its effects: the CADF unit root test by Pesaran (2007) and the panel cointegration tests by Westerlund (2007). Then we employed a grouping strategy based

[16] The coefficients of the cross-sectional mean are just control variables for the beta estimation, thus their interpretation is not relevant.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

on properties of revenue and expenses` time series for each state. This strategy leads to the identification of two groups of states: one comprising 9 states that meet the conditions of sustainability and the other containing 18 unsustainable states, as evidenced by suitable hypothesis tests. We also showed that the first group is sustainable only in the weak sense.

The identification strategy for panel cointegration tests to form sustainable and unsustainable subpanels also contributes to the literature by connecting some results from time series analyses to panel models. As far as we know, no previous work investigated the fiscal sustainability of the Brazilian states using panel techniques that incorporate cross-dependence and proposed a criterion based on time series properties and properly panel tests to identify and discriminate a sustainable and an unsustainable group of states.

This study's results have a clear practical application, which is making unsustainable states' governments aware of the unsustainable trajectory of their public finances, thereby highlighting the need to implement economic policies aimed at fiscal sustainability.

References

AFONSO, J. R. Federalismo Fiscal Brasileiro: uma visão atualizada. Caderno Virtual, v. 1, n. 34, 2016.

AFONSO, J. R..; FUCK, L. F.; CORREIA NETO, C. Ba.; and SZELBRACIKOWSKI, D. C.. Revista de Direito Internacional Econômico e Tributário (RDIET), Brasília, V. 12, nº1, p. 416 – 443, 2017.

AFONSO, J. R..; LUKIC, M. R.; and CASTRO; K. P.. ICMS: Federative crisis and obsolescence. Rev. direito FGV. Vol. 14, nº 3. P. 986-1018, 2018.

AFONSO, A.; SCHUKNECHT, L.; TANZI, V.. Public sector efficiency: an international comparison. *Public choice*, v.123, n.3, p.321-347, 2005.

AFONSO, A.; RAULT, C.. Multi-step analysis of public finances sustainability. *Economic Modelling*, v.48, p.199-209, 2015.

AKRAM, V.; RATH, B. N. What do we know about fiscal sustainability across Indian states?. Economic Modelling, v. 87, p. 307-321, 2020.

ALMEIDA, A. O. de. Evolução e crise da dívida pública estadual [*Evolution and crisis of the state public debt*]. Institute for Applied Economic Research (Ipea). Working paper nº 448, 1996.

ARENA, M. and REVILLA, Julio E., .. Pro-Cyclical Fiscal Policy in Brazil: Evidence from the States. World Bank Policy Research Working Paper No. 5144, 2009

BALTAGI, B. H.. Forecasting with panel data. Journal of forecasting, v. 27, n. 2, p. 153-173, 2008.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

BALTAGI, B. H.. Econometric analysis of panel data. *Chichester: John Wiley & Sons*, 2013.

BLANCHARD, O. J. et al. The cyclical behavior of the gross flows of US workers. Brookings papers on economic activity, v. 1990, n. 2, p. 85-155, 1990.

BOHN, H.. Budget balance through revenue or spending adjustments? Some historical evidence for the United States. Journal of monetary economics, v.27, n.3, p.333-359, 1991.

BOHN, H.. The sustainability of fiscal policy in the United States. *Sustainability of public debt*, p.15-49, 2008.

BURRET, H. T.; FELD, L. P.; KÖHLER, E. A.. (Un-) sustainability of public finances in German Laender: A panel time series approach. *Economic Modelling*, v.53, p.254-265, 2016.

CALDEIRA, A. A., WILBERT, M. D., MOREIRA, T. B. S.; SERRANO, A. L. M.. Sustentabilidade da dívida estadual brasileira: uma análise da relação dívida líquida e resultado primário. Revista de Administração Pública, v. 50, p. 285-306, 2016.

CHOW, G. C.; LIN. An-loh.. Best linear unbiased interpolation, distribution, and extrapolation of time series by related series. The review of Economics and Statistics, p. 372-375, 1971.

CHUDIK, A.; PESARAN, M. H.; TOSETTI, E.. Weak and strong cross-section dependence and estimation of large panels. 2011.

CODACE, Comitê de Datação de Ciclos Econômicos. Relatório. IBRE, FGV, 2020. Disponível em: https://portalibre.fgv.br/sites/default/files/2020-06/comunicado-do-comite-de-datacao-de-ciclos-economicos-29_06_2020-1.pdf.

DURAN-VÁZQUEZ, R.; LORENZO-VALDES, A.; RUIZ-PORRAS, A.. Valuation of Latin-American stock prices with alternative versions of the Ohlson model: An investigation of cointegration relationships with time-series and panel-data. 2011.

FERNANDES, A. L. and SANTANA, P.. Reforms of fiscal relations in Brazil: Main issues, challenges, and reforms. Organisation for Economic Co-operation and Development (OECD). Background paper. 14th Annual Meeting of the Network on Fiscal Relations Across Levels of Government. P. 19-20, 2018.

FOREMNY, D. Sub-national deficits in European countries: The impact of fiscal rules and tax autonomy. European Journal of Political Economy, v. 34, p. 86-110, 2014.

GIAMBIAGI, F.; TINOCO, G.; and DIAS, V. P. (Orgs.). O destino dos estados brasileiros: Liderança, responsabilidade fiscal e políticas públicas. São Paulo, Ed. Lux. 2021.

GUARDIA, E. R. and SONDER, D.. Fiscal Adjustment and Federalism in Brazil. At the IMF/NIPFP Conference on Fiscal Policy in India. Taj Mahal Hotel, New Delhi, India. January 16-17, 2004.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

GUISAN, M.-C. Causality and cointegration between consumption and GDP in 25 OECD countries: limitations of the cointegration approach. *Applied Econometrics and International Development*, v.1, n.1, 2001.

HAMILTON, J. D.; FLAVIN, M.. On the limitations of government borrowing: A framework for empirical testing. *The American Economic Review*. v.76, n.4, p. 808-819, 1985.

HAUG, Alfred A.. Cointegration and government borrowing constraints: Evidence for the United States. Journal of Business & Economic Statistics, v. 9, n. 1, p. 97-101, 1991.

HAKKIO, C. S.; RUSH, M.. Is the budget deficit "too large?". Economic inquiry, v. 29, n. 3, p. 429-445, 1991.

HSIAO, C.. Panel data analysis-advantages and challenges. Test, v.16, n.1, p.1-22, 2007.

ISSLER, J.V.; LIMA, L. R.. Public debt sustainability and endogenous seigniorage in Brazil: time-series evidence from 1947–1992. *Journal of development Economics*, v.62, n. 1, p.131-147, 2000.

ISSLER, J. V.; NOTINI, H. H.. Estimating Brazilian Monthly GDP: a State-Space Approach. Revista Brasileira de Economia, v. 70, p. 41-59, 2016.

JI, H.; AHN, J.; CHAPMAN, J.. The role of intergovernmental aid in defining fiscal sustainability at the sub-national level. Urban Studies, v. 53, n. 14, p. 3063-3081, 2016.

KAPETANIOS, G.; PESARAN, M. H.; YAMAGATA, T.. Panels with non-stationary multifactor error structures. *Journal of econometrics*, v.160, n.2, p.326-348, 2011.

KIRCHGÄSSNER, G.; PROHL, S.. Sustainability of Swiss fiscal policy. *Swiss Journal of Economics and Statistics*, v.144, n.1, p.57-83, 2008.

LARIN, B.; SÜSSMUTH, B.. Fiscal autonomy and fiscal sustainability: subnational taxation and public indebtedness in Contemporary Spain. 2014.

LI, T.; DU, T. Vertical fiscal imbalance, transfer payments, and fiscal sustainability of local governments in China. International Review of Economics & Finance, v. 74, p. 392-404, 2021.

LIMA, L. R. R. de O.; SIMONASSI, A. G.. Dinâmica não-linear e sustentabilidade da dívida pública brasileira. 2005.

LINHARES, F.; PENNA, C.; BORGES, G.. Os efeitos da Lei de Responsabilidade Fiscal no endividamento dos municípios do Piauí. *Revista de Administração Pública*, v.47, p.1359-1373, 2013.

LUPORINI, V.. Sustainability of the Brazilian fiscal policy and central bank independence. Revista brasileira de economia, v. 54, p. 201-226, 2000.

LUPORINI, V.. A sustentabilidade da dívida mobiliária federal brasileira: uma investigação adicional. Análise econômica, v. 19, n. 36, 2001.

LUPORINI, V.. Sustainability of Brazilian fiscal policy, once again: corrective policy response over time. Estudos Econômicos (São Paulo), v. 45, p. 437-458, 2015.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

MELLO, G. R.; SLOMSKI, V.. Factors that influence the debt of Brazilian States. Journal of Accounting and Organizations. V. 3, n.7, pp. 78-92, 2009.

MELLO, G.R.; SLOMSKI, V.. O Endividamento dos Estados Brasileiros: verificação da situação utilizando a Análise Multivariada de Dados. *Contabilidade Vista & Revista* v. 19, n. 1, p. 25, 2008.

MITZE, T.; MATZ, F.. Public debt and growth in German federal states: What can Europe learn?. Journal of Policy Modeling, v. 37, n. 2, p. 208-228, 2015.

MÖNCH, E.; UHLIG, H. Towards a Monthly Business Cycle Chronology for the Euro Area. Journal of Business Cycle Measurement and Analysis, p. 43-69, 2005.

MONTEIRO, S.. Apertar o cinto - macro fiscal. Conjuntura Econômica, v. 69, n. 2, p. 28, 2015.

NASCIMENTO, S. P.. Guerra fiscal: uma avaliação comparativa entre alguns estados participantes. Econ. Apl. V.12 n.4. p. 677-706, 2008.

NUNES, S. P.; MARCELINO, G F. and SILVA, C.A. T.. The Courts of Accounts on the interpretation of the Fiscal Responsibility Law. Journal of Accounting and Organizations. v. 13. Ed. 145151, 2019.

NUNES, R. da C. and NUNES, S. P.. Revenue sharing: A problem of federalism in Brazil. Brazilian Journal of Political Economy. v. 20, n.4 (80), p501-520, 2000.

PASTORE, A. Déficit Público, a Sustentabilidade do Crescimento das Dívidas Interna e Externa, Senhoriagem e Inflação: Uma Análise do Regime Monetário Brasileiro. Brazilian Review of Econometrics, v. 14, n. 2, p. 177-234, 1994.

PELLEGRINI, J.A.. Análise da situação fiscal dos estados. Estudo Especial nº14, Instituição Fiscal Independente. 2020

PERSYN, D.; WESTERLUND, J.. Error-correction–based cointegration tests for panel data. *The STATA journal*, v.8, n.2, p.232-241, 2008.

PESARAN, M. H.. General diagnostic tests for cross section dependence in panels. IZA Discussion Paper, 2004.

PESARAN, M. H.. Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, v.74, n.4, p.967-1012, 2006.

PESARAN, M. H.. A simple panel unit root test in the presence of cross-section dependence. *Journal of applied econometrics*, v.22, n.2, p.265-312, 2007.

PESARAN, M. H.. Testing weak cross-sectional dependence in large panels. *Econometric reviews*, v.34, n.6-10, p.1089-1117, 2015.

PINTO, V. da C.; BARROS, G. L. de; and AFONSO, J. R. R.. A expansão acelerada das garantias pelo Tesouro Nacional. Texto para Discussão, FGV – IBRE, 2014.

QUINTOS, C.E. Sustainability of the deficit process with structural shifts. *Journal of Business & Economic Statistic*s, v.13, n.4, p.409-417, 1995.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

RIGOLON, F.; GAMBIAGI, F.. A renegociação das dívidas e o regime fiscal dos Estados. Textos para discussão. *Revista do BNDES.* 1999.

ROCHA, F.. Long-run limits on the Brazilian government debt. *Revista brasileira de economia*, v.51, n.4, p.447-470, 1997.

SANTOS, D. F.C. dos. Situação financeira dos estados em dez anos da Lei de Responsabilidade Fiscal. Ministério da Fazenda, XV Prêmio Tesouro Nacional-2010: Homenagem a Joaquim Nabuco, 2010.

SANTOS SILVA, J. M. C.; CARDOSO, F. N.. The Chow-Lin Method Using Dynamic Models. Economic Modelling, v. 18 n. 2, p. 269-280, 2001.

SERRA, J. and AFONSO, J. R. R.. Fiscal federalism in Brazil: an overview. CEPAL review. Vol. 91. p. 29 – 51. 2007.

SIMONASSI, A. G.; GONDIM FILHO, J. G.; ARRAES, R. A.. Endividamento e investimentos dos governos subnacionais no Brasil: uma análise via funções de reação. Nova Economia, v.31, p.783-807, 2021.

SILVA, I.F.B.R.; SOUSA, M.da C.S.. Determinantes do endividamento dos estados brasileiros: uma análise de dados de painel. Série Textos para Discussão, 2002.

TAVARES, R.de S., SCHEFFLER, I.L., GUIMARÃES, G.S.P.. Processo de Endividamento Brasileiro: uma Análise de Sustentabilidade para o Século XXI. *Revista Economia Ensaios*, v.34, n.2, p.1983-994, 2020.

TINOCO, G.. A sustentabilidade fiscal dos estados brasileiros: análise recente e notas para o futuro. Revista do BNDES, Rio de Janeiro, v. 25, n. 50, p. 299-344, 2018.

TREHAN, B.; WALSH, C.E.. Common trends, the government's budget constraint, and revenue smoothing. Journal of Economic Dynamics and Control, v.12, n.2-3, p.425-444, 1988.

TRICHES, D.; BERTUSSI, L. A. S.. Multicointegração e sustentabilidade da política fiscal no Brasil com regime de quebras estruturais (1997-2015). Revista Brasileira de Economia, v. 71, p. 379-394, 2017.

WESTERLUND, J.. Testing for error correction in panel data. *Oxford Bulletin of Economics and statistics*, v.69, n.6, p.709-748, 2007.

About the authors

Eduardo Lima Campos - *eduardolimacampos@yahoo.com.br*
EPGE Brazilian School of Economics and Finance (FGV EPGE), Rio de Janeiro, RJ, Brazil.
National School of Statistical Sciences (ENCE/IBGE), IBGE, Rio de Janeiro, RJ, Brazil.
ORCID: https://orcid.org/0000-0002-7294-8947

Rubens Penha Cysne - R*ubens.Cysne@fgv.br*
EPGE Brazilian School of Economics and Finance (FGV EPGE), Rio de Janeiro, Brazil.
ORCID: https://orcid.org/0000-0001-7474-0237

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Acknowledgment

The authors thank Vilma C. Pinto, Director of the Independent Fiscal Institution of Brazil, for useful comments and Carlos Henrique Dias Cordeiro de Castro, Otávio Cypriano and Edilson Figueiredo for research assistance.

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Authors' contribution

Both authors worked together on the text and empirical estimations

About the article

Submission received on April 27, 2022. Approved for publication on November 02, 2022.

Conflict of interest statement

The authors declare that there are no conflicts of interest of personal, commercial, academic or financial nature between the authors and the publication of this article.

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Annex I

Table A.1 - Individual Stationarity and Cointegration Test

UF	Expenses I(1)?	Revenue I(1)?	Cointegration?	Estimated β	β < 1?
Acre	✓	✓	✓	0.12	Yes
Alagoas	✓	✓	✓	0.79	Yes
Amapá	✓	✓	✓	0.35	Yes
Amazonas	✓	✓	X	-	-
Bahia	✓	✓	X	-	-
Ceará	✓	✓	X	-	-
Distrito Federal	✓	✓	✓	0.64	Yes
Espírito Santo	✓	✓	✓	0.78	Yes
Goiás	✓	✓	X	-	-
Maranhão	✓	✓	X	-	-
Mato Grosso	✓	✓	X	-	-
Mato Grosso do Sul	✓	✓	X	-	-
Minas Gerais	✓	✓	X	-	-
Pará	✓	✓	✓	0.91	Yes
Paraíba	✓	✓	X	-	-
Paraná	✓	✓	✓	0.67	Yes
Pernambuco	✓	✓	X	-	-
Piauí	✓	✓	✓	0.95	Yes
Rio de Janeiro	✓	✓	X	-	-
Rio Grande do Norte	✓	✓	✓	0.18	Yes
Rio Grande do Sul	✓	✓	X	-	-
Rondônia	✓	✓	X	-	-
Roraima	✓	✓	X	-	-
Santa Catarina	✓	✓	X	-	-
São Paulo	✓	✓	X	-	-
Sergipe	✓	✓	X	-	-
Tocantins	✓	✓	X	-	-

Note: Details of Individual Unit Root Tests ADF and Johansen Cointegration Tests are available from https://www.dropbox.com/s/ssmujqfwzemvism/Individual%20Unit%20Root%20Tests%20ADF.pdf?dl=0 and https://www.dropbox.com/s/d9e9jy7bzn2ftkd/Johansen%20Cointegration%20Tests.pdf?dl=0

Annex II

Table A.2 - Results of Westerlund Cointegration Tests Without Dummies

	Whole panel			**Subpanel 1**			**Subpanel 2**		
	Value	Z-value	Robust p-value	Value	Z-value	Robust p-value	Value	Z-value	Robust p-value
Gt	-8.659	-2.298	0.026	-1.989	-1.457	0.054	-3.896	-2.456	0.044
Ga	-7.982	-1.282	0.072	-7.925	-1.398	0.028	-8.824	-2.402	0.033
Pt	-2.518	0.623	0.707	-4.846	-0.562	0.574	-6.651	-1.999	0.020
Pa	-2.007	-1.058	0.366	-5.437	-0.988	0.326	-9.002	-3.410	0.009

Article approved for publication in volume 33, issue 1, 2023 of the Revista Nova Economia. Article in editing final stage. This text is a preliminary version of the article accepted for publication, made available in the SciELO Preprints database. DOI: http://dx.doi.org/10.1590/0103-6351/7588.

Annex III

Table A.3 - CCE Estimates - Subpanel 2

UF	β_i	Std. error	t-stat (β=1)	p-value	μ_1	t-stat (μ_1=0)	p-value	μ_2	t-stat (μ_2=0)	p-value	α	t-stat (α =0)	p-value
AC	0.112	0.069	12.87	0.107	2.499	0.146	0.000	-0.665	0.183	0.000	-0.027	0.024	0.260
AL	0.243	0.042	18.02	0.000	0.434	0.083	0.000	0.095	0.079	0.229	0.037	0.015	0.012
AP	0.291	0.031	22.87	0.000	1.960	0.126	0.000	-0.853	0.151	0.000	0.020	0.018	0.261
DF	0.453	0.038	14.39	0.000	0.056	0.030	0.060	0.055	0.030	0.067	0.024	0.005	0.000
ES	0.602	0.060	6.67	0.000	0.61	0.055	0.000	-0.37	0.047	0.000	0.01	0.008	0.523
PA	0.854	0.040	3.65	0.000	0.365	0.052	0.000	-0.231	0.049	0.000	-0.004	0.008	0.640
PR	0.339	0.054	12.24	0.000	0.269	0.055	0.000	-0.243	0.056	0.000	0.062	0.009	0.000
PI	0.318	0.059	11.56	0.000	1.847	0.179	0.000	-0.566	0.140	0.000	-0.094	0.029	0.001
RN	0.287	0.046	15.50	0.000	0.526	0.072	0.000	0.123	0.075	0.100	0.002	0.012	0.833

This preprint was submitted under the following conditions:

- The authors declare that they are aware that they are solely responsible for the content of the preprint and that the deposit in SciELO Preprints does not mean any commitment on the part of SciELO, except its preservation and dissemination.
- The authors declare that the necessary Terms of Free and Informed Consent of participants or patients in the research were obtained and are described in the manuscript, when applicable.
- The authors declare that the preparation of the manuscript followed the ethical norms of scientific communication.
- The authors declare that the data, applications, and other content underlying the manuscript are referenced.
- The deposited manuscript is in PDF format.
- The authors declare that the research that originated the manuscript followed good ethical practices and that the necessary approvals from research ethics committees, when applicable, are described in the manuscript.
- The authors declare that once a manuscript is posted on the SciELO Preprints server, it can only be taken down on request to the SciELO Preprints server Editorial Secretariat, who will post a retraction notice in its place.
- The authors agree that the approved manuscript will be made available under a Creative Commons CC-BY license.
- The submitting author declares that the contributions of all authors and conflict of interest statement are included explicitly and in specific sections of the manuscript.
- The authors declare that the manuscript was not deposited and/or previously made available on another preprint server or published by a journal.
- If the manuscript is being reviewed or being prepared for publishing but not yet published by a journal, the authors declare that they have received authorization from the journal to make this deposit.
- The submitting author declares that all authors of the manuscript agree with the submission to SciELO Preprints.