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Tax Revenues and State Expenditures in the US with Balanced-Budget Requirements Using Panel VAR*

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Abstract: We examine Granger causality between state expenditures and tax revenues in the US with Balanced-Budget Requirements (BBRs). BBRs are statutory or constitutional rules to prevent states from spending more than tax revenues. Policymakers may adjust taxes, change expenditures, or do both to achieve BBRs. Panel VAR is introduced to address endogenous interactions between state expenditures and tax revenues. Panel VAR provides a unifying empirical framework and identification strategy which might be lacking in the previous literature. The empirical result supports that tax revenues Granger cause state expenditures. As BBRs are about planning, tax revenues make states plan on how to spend them. Considering BBRs with the empirical results from this study, states expenditures should be adjusted close to (projected) tax revenues. Additionally, this study finds that the business cycle has counter-intuitive effects. Tax revenues did not change when the US experienced the recession during 2008-2009 with the increases in intergovernmental transfer from the federal. State expenditures also increased during the recession.

Keywords: balanced-budget requirements, Granger causality, panel VAR, tax-and-spend hypothesis

JEL Codes: C22, C23, H20, H30

1. INTRODUCTION

Tax revenues and expenditures are the core of fiscal policy and are essential in public decisions, particularly in correcting the fiscal imbalances (Owoye and Onafowora, 2011). Many of the US states have Balanced Budget Requirements (BBRs), which are statutory or constitutional rules[1], and prevent states from spending more than their tax revenues (NCSL, 2010; Tax Policy Center, 2020a). BBRs obligate states to balance spending with projected

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[1] Stricter BBRs prevent states from transferring deficits to the next fiscal year even though scholars have disputed how to categorize the relative strength of BBR (NCSL, 2010; Tax Policy Center, 2020b). According to Tax Policy Center (2020b), a strong BBR state should meet at least one of the following requirements: 1) the governor to sign a balanced budget, 2) prohibits the state from budget deficits, and 3) the legislature must pass a balanced budget.

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revenues, even though there is flexibility in achieving the requirement. Previous studies such as Alt and Lowry (1994); Bohn and Inman (1996); Campbell and Sances (2013); Crain and Miller (1990); Poterba (1994) concluded that stricter BBRs result in tighter state fiscal outcomes.

BBRs require policymakers to raise taxes, cut expenditures, or both when the economy is in recession and the exact opposite when the economy is expanding (Kogan, 2018). Policymakers raise taxes and cut spending when the deficit is small; they combine asset sales, raising taxes and spending cuts when the deficit is large (Costello et al., 2015). As Payne (1998) pointed out, "Policymakers are confronted with the dilemma of either changing expenditures or taxes" (p.307). BBRs imply that states are not able to increase expenditures without eventually raising taxes, i.e., expenditures cause tax revenues. And states would raise taxes to provide more services to taxpayers, i.e., tax revenues cause expenditures. A bidirectional causality may exist as both expenditures and tax revenues can be adjusted to achieve BBRs.

There are four hypotheses concerning how tax revenues are associated with expenditures: tax-and-spend hypothesis, spend-and-tax hypothesis, fiscal synchronization, and institutional separation. The first hypothesis is tax-and-spend, which argues that adjustments in tax revenues make changes in expenditures (Friedman, 1978). It implies that more tax revenues lead to more expenditures. The second hypothesis proposed in Peacock and Wiseman (1979) is spend-and-tax, which suggests that temporary increases in government spending cause permanent expansion in revenues. Fiscal synchronization is the third hypothesis, and it argues that tax revenues and expenditures are considered simultaneously when policymakers make decisions (Musgrave, 1966). Fourth, the institutional separation hypothesis points out that tax revenues and expenditures are independent of each other, and there is no causal relationship between these two (Baghestani and McNown, 1994). Owoye and Onafowora (2011) indicated that previous studies have provided mixed results since there is no economic theory explaining these hypotheses. Previous studies failed to find underpinning common patterns in their study regions.

Due to BBRs, which means that both tax revenues and state expenditures need to be changed at least close to one another, institutional separation might be unlikely valid for the case of the US states. The present paper attempts to extend the existing studies by examining a causal direction between tax revenues and expenditures in the US states. It is a central question to policymakers because the investigation of causal relationships may provide how BBRs have affected the finances of states, as Marlow and Manage (1987) pointed out. Saunoris (2013) mentioned that investigating the relationship between state expenditures and tax revenues in BBRs helps policymakers to manage the budget effectively. For example, if tax-and-spend explains the relationship, then adjusting tax revenues will change state expenditures, i.e., cutting tax reduces spending. If spend-and-tax is valid, then cutting tax will result in inadequately planned spending cuts (Saunoris, 2013). The primary goal of the present paper is to analyze the dynamics between state expenditures and tax revenues with BBRs in the US using a panel VAR framework proposed by Love and Zicchino (2006).

We apply the Panel VAR model to tax revenues and state expenditures data for the US from 2004 to 2020 and examine the dynamic relationship between these two. One of the advantages of the panel VAR model is that both tax revenues and state expenditures

are treated endogenously. In other words, in the VAR system, both tax revenues and state expenditures interact. The VAR approach considers that tax revenues could have an effect on state expenditures; at the same time, state expenditures can influence tax revenues. Many previous studies adopted the VAR approach and Granger causality as summarized in Table A1, in Appendix. Panel data allow us to consider state-specific unobserved heterogeneity in state expenditures and tax revenues, which is one of the contributions of this study. In the US, tax policy varies from state to state. For example, some states have strong BBRs, and some states have weak BBRs (NCSL, 2010; Tax Policy Center, 2020b). And some states have no income tax. Five states do not have statewide sale taxes, while California has a high state-level sales tax rate of 7.25%. As such, panel-specific fixed effects should be modeled properly to answer the research question (Abrigo and Love, 2016). In short, panel VAR addresses endogenous interactions between tax revenues and state expenditures. It provides an integrating empirical approach and identification strategy, which might be lacking in the previous study.

Our empirical result finds that tax revenues Granger cause state expenditures which supports the tax-and-spend hypothesis. It implies that adjusting taxes will change state expenditures. For example, cutting taxes reduces expenditures or vice versa. In other words, as BBRs are about planning, more or lower tax revenues make states plan on how to spend them. Considering BBRs with the empirical results from this study, states expenditures should be adjusted close to (projected) tax revenues. The panel VAR approach identifies that tax revenues have positive effects on state expenditures.

The remainder of the present study is organized as follows: Section 2 provides a summary of the related works, and the data we use are discussed in Section 3. Section 4 explains the panel VAR model, and Section 5 discusses the results. Section 6 summarizes this study with policy implications.

2. LITERATURE REVIEW

Friedman (1978) proposed the tax-and-spend hypothesis and suggested that raising taxes will result in more government spending. Peacock and Wiseman (1979) suggested the spend-and-tax hypothesis, which argued the short-term increase in government expenditure might lead to a permanent increase in tax revenue. The fiscal synchronization hypothesis was introduced by Musgrave (1966) and Meltzer and Richard (1981). Fiscal synchronization is valid when there exists a bidirectional causality between tax revenues and expenditures (Payne, 1998). The institutional separation hypothesis concluded that both are independent. Thus no causality between these two exists.

A decent amount of studies have focused on the relationship between expenditures and tax revenues. They provided evidence for the above four hypotheses. Spend-and-tax was supported by Chang et al. (2002), Darrat (2008), Dritsaki (2018), Karlsson (2019), and Siami-Namini et al. (2018). However, the opposite direction of the causal relationship was suggested in Kazungu (2019), Lojanica (2015),Saunoris and E (2010) Reddick (2002), and Zapf and Panye (2009). These studies have proved the tax-and-spend hypothesis. Some studies such as Hasan and Lincoln (1995), Irandoust (2018), and Vamvoukas (2012) found a bi-directional causal relationship between expenditures and tax revenues, which supports

fiscal synchronization. Independence between expenditures and tax revenues was founded in Baghestani and McNown (1994), Chang et al. (2002), Kollias and Makrydakis (2000) and Mendoza et al. (1997). See Table A1, which summarizes the previous studies, including study regions, primary methodologies used, and conclusions. Many of them used the Grager-type causality test on time series data with vector autoregression (VAR) or vector error correction model (VECM). A few studies utilized cross-sectional data. Depending on study regions, sample periods, and modeling strategies, they arrived at different results. Note that, to the best of the authors' knowledge, there is no study using the Panel VAR approach.

Studies investigating the US have also arrived the different conclusions. Blackley (1986), Manage and Marlow (1986), Owoye (1995), and Ram (1988) all supported the tax-and-spend hypothesis. However Anderson et al. (1986), Jones and Joulfaian (1991), and von Furstenberg et al. (1986) found the opposite causal relationship and supported the spend-and-tax hypothesis. Fiscal synchronization was supported by Miller and Russek (1990) while Baghestani and McNown (1994) found evidence that fiscal independence, that is, neither expenditure nor tax revenue, is affected by budgetary disequilibria. Hoover and Sheffrin (1992) found that tax revenue causes government spending prior to the mid-1960s in the US, but both seem to be independent after the mid-1960s. Unlike the previous studies, Hoover and Sheffrin (1992) modeled the long-run intertemporal relationship between (state level) tax revenues and expenditures.

Empirical studies utilizing state and local data have yielded mixed results as well. Using both annual and quarterly data over the period 1946 to 1987, Miller and Russek (1990) showed that there exists a bi-directional causality between expenditure and tax revenue at the local and state level. Marlow and Manage (1987, 1988) with annual data from 1952 to 1982 across states and local found that the unidirectional causal flow runs to expenditures from tax revenues at the state level but not the local level. Conversely, Ram (1988) revealed that expenditures cause tax revenues. Chowdhury (1988) re-investigated the findings in Marlow and Manage (1987) and showed that the bi-directional causality exists between local expenditures and tax revenue. Payne (1998) applied VECM to the individual state-level budget data and concluded that tax-and-spend is valid for twenty-four states, spend-and-tax for eight states, and fiscal synchronization for eleven states. Zapf and Panye (2009) used a symmetric error correction model and provided evidence for spend-and-tax.

This study attempts to examine which hypothesis is valid for US states with BBRs using the panel VAR. Data are compiled from Urban-Brookings Tax Policy Center between 2004 and 2020. The panel VAR addresses endogenous interactions between tax revenues and state expenditures. It provides an integrating empirical approach and identification strategy, which might be lacking in the previous studies.

3. DATA

The dataset contains all 50 states and Washington DC (DC hereafter) and covers the period from 2004 to 2020 (17 years). We dropped Wyoming and North Dakota from the sample as Tax Policy Center (2020b) and classified these two states as non-BBR states (see Figure 1 on page 2 in Tax Policy Center (2020b)). As such, we have 48 states and DC in the dataset, and a total of 833 observations (48 states and DC $\times$ 17 years) are available.

Table 1: Tax Revenue and Expenditures over Years[a] (2012 $/person)

Variable	2010 mean (stDev)	2015 mean (stDev)	2020 mean (stDev)
All 49 states[b]			
Tax revenue	8,718 (2,443)	8,782 (2,176)	9,724 (2,170)
Government expenditure	8,735 (2,301)	8,627 (2,406)	9,225 (2,327)
Nine States with Weak BBR[c]			
Tax revenue	8,287 (1,094)	8,575 (1,451)	9,701 (1,730)
Government expenditure	8,355 (1,102)	8,335 (1,416)	8,955 (1,439)
Seven States with Statutory BBR[d]			
Tax revenue	11,524 (5,255)	10,944 (4,055)	11,720 (3,881)
Government expenditure	11,348 (4,931)	11,354 (4,926)	11,657 (4,596)
33 States with Constitutional BBR[e]			
Tax revenue	8,199 (1,226)	8,343 (1,533)	9,270 (1,586)
Government expenditure	8,253 (1,172)	8,100 (1,327)	8,761 (1,474)

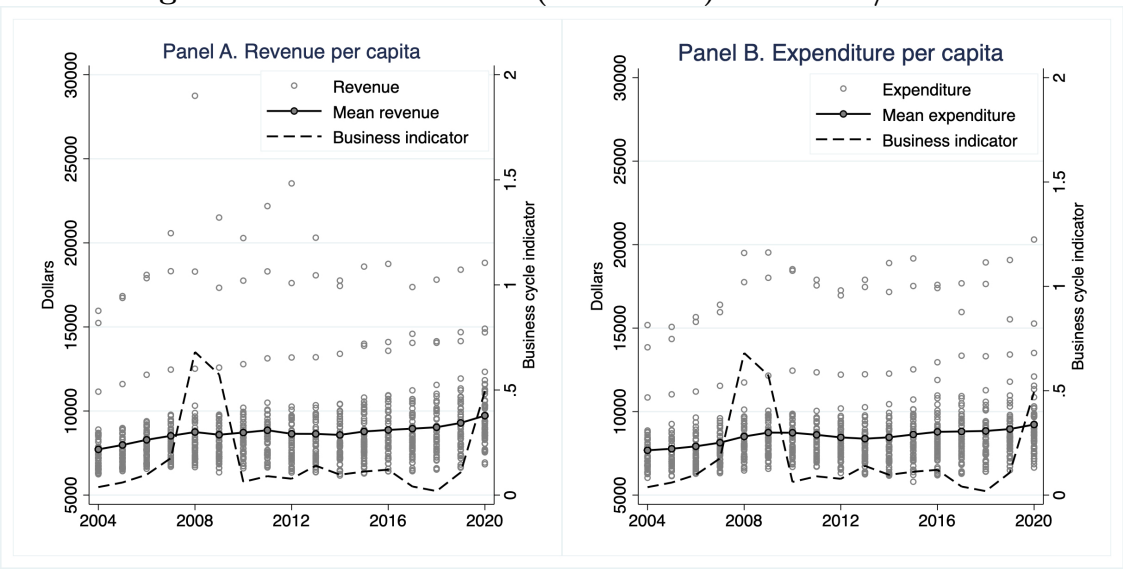
Note:
[a] Data source is Tax Policy Center, https://www.taxpolicycenter.org/statistics. Units of tax revenue and expenditure are $/person and deflated with GDP deflator (2012 = 100).
[b] 48 states except North Dakota and Wyoming, which do not have balanced budget requirements, and Washington DC following classification in Tax Policy Center (2020b)
[c] Weak BBR states have balanced budget requirements but are not statutory nor constitutional following classification in Tax Policy Center (2020b). There are nine states, for example, Maine, Vermont, Pennsylvania, Indianan, Tennessee, Iowa, Missouri, Nebraska, and New Mexico.
[d] Statutory BBR states indicate that BBRs are statutory, for example, New Hampshire, Rhode Island, Massachusetts, Washington DC, Mississippi, Alaska, and Washington (seven states), and
[e] Constitutional BBR states are the states which have constitutional BBR requirements. There are 33 states.

Two variables of interest are (annual) tax revenues per person[2] and state expenditures per person[3] which are collected from Urban-Brookings Tax Policy Center (https://www.taxpolicycenter.org/statistics). Tax Policy Center provides tax information compiled from various sources such as the Congressional Budget Office, Department of the Treasury, Federation of Tax Administration, Internal Revenue Service (IRS), Urban Institution, etc. Table 1 provides the summary statistics of the data over the selected years, 2010, 2015, and 2020 for comparison purposes. Tax revenues and state expenditures are used in the empirical analyses in the following sections to answer which tax and spending hypotheses are valid for the US states during the sample period. Note that tax revenues and state expenditures are deflated using the GDP deflator from the US Bureau of Economic Analysis.

As shown in Table 1, we split the dataset into three groups, that is, 1) weak BBR states,

[2] Tax revenues include intergovernmental from federal, property, sales, individual income, corporate income, charges and miscellaneous general revenues such as lottery revenues.
[3] State expenditures include intergovernmental transfer, education, public welfare (Medicaid), health and hospitals, highways, police and others such as corrections, housing & community development and courts.

Figure 1: Basic Statistics (2004-2020) in 2012 $/Person



Note: Dashed line represents the business cycle indicator (GDP-based Recession Indicator Index, which measures the probability that the US economy was in a recession)
Source: Urban-Brookings Tax Policy Center (https://www.taxpolicycenter.org/statistics).

2) statutory BBR states, and 3) constitutional BBR states, to get more insights following the classification in Tax Policy Center (2020b). Weak BBR states are the states where BBR is not statutory or constitutional. There are nine states (see Figure 1 on page 2 in Tax Policy Center (2020b)), for example, Maine, Vermont, Pennsylvania, Indianan, Tennessee, Iowa, Missouri, Nebraska, and New Mexico. Statutory BBR states indicate that BBRs are statutory, for example, New Hampshire, Rhode Island, Massachusetts, Washington DC, Mississippi, Alaska, and Washington (seven states) (see Figure 1 on page 2 in Tax Policy Center (2020b)). Lastly, constitutional BBR states are the states which have constitutional BBR requirements. There are 33 states. Tax Policy Center (2020b) pointed out that "...while constitutional or statutory designations do not necessarily determine whether a rule is strong or weak, constitutional requirements can be more difficult to override and may require a legislative supermajority or vote of the people to amend..." (Tax Policy Center, 2020b, p. 2)

The average tax revenues per person for all states (48 states and DC) in 2020 $9,724, and the average state expenditures per person in 2020 was $9,225, which implies that the average fiscal balance per person was around $499/person in 2020. States with statutory BBRs have higher means of revenues and expenditures, that is, in 2020, $11,720 and $11,657, respectively, with $63 fiscal balance per person. This is mainly because DC and Alaska have much higher per-person tax revenues and state expenditures; both DC and Alaska have about $17,500 per person of tax revenues and state expenditures in 2020.

We expect that there exist heterogeneities since the US states have different BBRs, and tax systems and vary in size. Figure 1 is generated to show the heterogeneity and dynamics of these two variables for all 48 states and DC. The solid lines in Panels A and B in Figure 1 are the average of tax revenues per person and total expenditures per person across states in dollars. Figure 1 clearly shows that there exists heterogeneity across states. Panels A and B in Figure 1 also plot business cycle indicator, which may have effects on tax revenues and

expenditures. We selected the GDP-based Recession Indicator Index, which measures the probability that the US economy is in a recession. Large values of the indicator represent that the US experiences recession (Hamilton, 2022). See the indicator for the years 2008 and 2009 and also the year 2020 in Figure 1. During the 2008-2009 recession, tax revenues depicted in Figure 1 exhibited some ambiguity, showing a tendency to remain steady or experience a slight decrease. However, state expenditures notably demonstrated a counter-intuitive trend of clear increase throughout the recession period. With the recession during 2008-2009, tax revenues, were not clear from Figure 1 but remained or slightly decreased. In the case of state expenditures, they were clearly increased during the recession, which might be counter-intuitive.

4. METHODOLOGY

This section introduces the panel VAR and estimation strategy with the Helmert transformation to test which tax-and-spending hypotheses are valid during the sample period in the US states.

4.1. Panel VAR

The panel Vector Autoregression (VAR) combines the panel data with the VAR method. As aforementioned, the panel VAR approach treats variables in the VAR system as endogenous. The panel VAR model identifies short-run dynamic relationships (Koutsomanoli-Filippaki and Mamatzakis, 2009). It allows for unobserved individual heterogeneity with the panel data (Love and Zicchino, 2006) as well. The impulse response functions (IRFs) provide graphs that present the interrelationship between variables in the system by presenting the responses of one variable, for example, tax revenues, to other variables, for example, state expenditures. IRFs describe the impact of one variable graphically while maintaining all other variables constant (Hamilton, 1994).

The reduced form of the general panel VAR model is given by:

$$\mathbf{y}_{it} = \mathbf{b}(\mathbf{L})\mathbf{y}_{it} + \mathbf{f}_i + \mathbf{u}_{it} \tag{1}$$

where $\mathbf{y}_{it}$ is a 2×1 vector with tax revenues per person (rvn) and state expenditures per person (exp) or $\mathbf{y}_{it} = (y_{it}^{\text{rvn}}, y_{it}^{\text{exp}})'$. The subscript i in Equation (1) denotes states, and the subscript t represents the year. $\mathbf{b}(\mathbf{L})$ is a vector of the polynomial lag operators, which is $\mathbf{b}(\mathbf{L}) = b_1(L^1) + b_2(L^2) + \cdots + b_k(L^k)$. A state-specific and time-invariant effect, $\mathbf{f}_i$, is added to control unobserved heterogeneity (e.g., BBRs, tax system, size of states, etc.). Lastly, $\mathbf{u}_{it}$ denotes a vector containing idiosyncratic innovations, $\mathbf{u}_{it} \overset{\text{i.i.d}}{\sim} N(\mathbf{0}, \mathbf{\Omega})$.

The panel VAR model requires the same basic structure for each state (Love and Zicchino, 2006), which is usually not satisfied in practice. A remedy is allowing individual heterogeneity, that is, $\mathbf{f}_i$, the fixed effects in Equation (1). However, the fixed effect is correlated with lagged dependent variables (Nickell, 1981), which may cause biased estimates. To address this issue, the Helmert transformation is utilized (Arellano and Bover, 1995; Love and Zicchino, 2006). The fixed effects, $\mathbf{f}_i$, in Equation (1) will be removed when the Helmert

transformation is applied. Lagged regressors work as instruments because the orthogonality between lagged regressors and transformed variables is maintained. The system GMM is used to estimate transformed panel VAR as suggested in Arellano and Bover (1995).

4.2. Helmert Transformation

Let y_{it}^p where $p = \text{rvn, exp}$, represent a variable in $\mathbf{y}_{it}$ and $\bar{y}_{it}^p$ is the mean of a corresponding variable. Then we define $\tilde{y}_{it}^p$ as following:

$$\tilde{y}_{it}^p = \frac{1}{(T-t)} \sum_{n=t+1}^{T} y_{in}^p, \quad p = \text{rvn, exp} \tag{2}$$

where $\tilde{y}_{it}^p$ is the means of future values of y_{it}^p and T indicates the last sample period of data. Let

$$\tilde{u}_{it}^p = \frac{1}{(T-t)} \sum_{n=t+1}^{T} u_{in}^p, \quad p = \text{rvn, exp} \tag{3}$$

where $\tilde{u}_{it}^p$ represents the forward mean of u_{it}^p. To find the Helmert-transformed model, we subtract these forward means from Equation (1) to eliminate the fixed effects, which is given by:

$$\lambda_{it}(\mathbf{y}_{it} - \tilde{\mathbf{y}}_{it}) = \lambda_{it}\mathbf{b}(\mathbf{L})(\mathbf{y}_{it} - \tilde{\mathbf{y}}_{it}) + \lambda_{it}(\mathbf{u}_{it} - \tilde{\mathbf{u}}_{it}) \tag{4}$$

where $\lambda_{it} = \sqrt{\frac{T-t}{(T-t+1)}}$.

The Helmert transformation is the difference between t^{th} and $(t+1)^{th}$ observations through T as shown in equations (2) and (3). In other words, it is the mean of all future observations. The Helmert transformation for the last observation cannot be computed since no future value exists.

4.3. Empirical Model

Equation (1) with the Helmert transformation can be written as follows:

$$\hat{\mathbf{y}}_{it} = \mathbf{b}(\mathbf{L})\hat{\mathbf{y}}_{it} + \hat{\mathbf{u}}_{it} \tag{5}$$

where $\hat{\mathbf{y}}_{it} = (\hat{y}_{it}^{\text{rvn}}, \hat{y}_{it}^{\text{exp}})'$, $\hat{\mathbf{u}}_{it} = (\hat{u}_{it}^{\text{rvn}}, \hat{u}_{it}^{\text{exp}})'$, $\hat{y}_{it}^p = \lambda_{it}(y_{it}^p - \tilde{y}_{it}^p)$, and $\hat{u}_{it}^p = \lambda_{it}(u_{it}^p - \tilde{u}_{it}^p)$ as in equation (4). $\hat{\mathbf{y}}_{it}$ and $\hat{\mathbf{u}}_{it}$ are deviations from the mean of future observations. The observation, which is closer to the initial period, has more weight. In addition, serial correlation is not induced, and homoscedasticity is preserved (Arellano and Bover, 1995).

After estimating coefficients in Equation (5), the IRFs are created. As aforementioned, the IRFs present graphs that show the interrelationship between variables in the system by presenting the responses of tax revenues or state expenditures to tax revenues or state expenditures. Confidence intervals for each IRF can be estimated with Monte Carlo simulation (Love and Zicchino, 2006). Unfortunately, the variance-covariance matrix of the innovations, $\hat{\mathbf{u}}_{it}$, might not be diagonal. Thus the innovations should be decomposed to be orthogonal and to separate the shocks on each variable in the system. We used the Cholesky decomposition

Table 2: Im–Pesaran–Shin[1] Panel Unit-root Test[2]

Sub-samples	Variables	$Z_{\tilde{t}-bar}$	P-value
All 49 states	ln rvn	5.39	1.00
	ln exp	1.69	0.95
Weak BBR States	ln rvn	4.37	1.00
	ln exp	1.12	0.86
Statutory BBR States	ln rvn	1.00	0.84
	ln exp	0.35	0.64
Constitutional BBR States	ln rvn	4.09	1.00
	ln exp	1.39	0.92

Note:
[1] The IPS test allowing for heterogeneous panels with serially uncorrelated errors assumes that the number of time is fixed (Im et al., 2003),
[2] H_0: all panels contain a unit root or panel-specific autoregressive parameter, $\phi_i = 0$ vs. H_a: Some panels are stationary

to compute IRFs. The Cholesky decomposition assumes a variable that comes earlier has a contemporaneous effect on the following variables and with lagged variables in the system (Hamilton, 1994). The series that appear later only have an impact on the previous series through a lag. More specifically, series that come earlier in the decomposition are treated to be more exogenous than the series that come later.

5. EMPIRICAL RESULTS

This section explains the steps of estimating equation (5) and presents the empirical results. The first step is to test if y_{it}^{rvn} and y_{it}^{exp} contain unit roots. For the analysis, all the series are log-transformed, and variables are defined as follows: $\ln \text{rvn} = \ln y_{it}^{\text{rvn}}$ and $\ln \text{rvn} = \ln y_{it}^{\text{exp}}$.

5.1. Panel Unit Root

Im–Pesaran–Shin (IPS) panel unit-root test (Im et al., 2003) without a trend is applied to determine the nonstationarity of the variables as a VAR system requires both tax revenues and state expenditures to be stationary. The IPS test allows for heterogeneous panels meaning that it relaxes the assumption of a common autoregressive parameter and has panel-specific parameter (Im et al., 2003). In addition, the IPS test allowing for heterogeneous panels with serially uncorrelated errors assumes that the number of time, T, is fixed (Im et al., 2003). Table 2 presents IPS panel unit-root test results. We conclude that ln rvn and ln exp are nonstationary for all four different groups. As such, to estimate equation (5), we used the differences in ln rvn and ln exp, that is, $\Delta \ln \text{rvn}$ and $\Delta \ln \text{exp}$.

5.2. Panel VAR Estimation

We estimate four panel VAR models described in Equation (5) with STATA PVAR package (Abrigo and Love, 2016; Love and Zicchino, 2006), that is, all 49 regions, weak BBR states,

Table 3: Selecting Optimal Lag Length for Panel VAR

	Lag	MAIC	MBIC	MQIC
All 49 states	1	43.19	−25.44*	16.35
	2	46.68	−4.79	26.55
	3	37.44	3.12	24.02
	4	16.78*	−0.38	10.06*
Weak BBR states	1	0.38	−41.13*	−16.41*
	2	−0.49*	−31.64	−13.09
	3	0.91	−19.86	−7.49
	4	3.08	−7.30	−1.12
Statutory BBR states	1	−5.52	−43.03*	−20.52*
	2	−4.59	−32.71	−15.84
	3	−4.94	−23.69	−12.44
	4	−5.68*	−15.06	−9.44
Constitutional BBR states	1	26.10	−36.21*	1.33*
	2	37.35	−9.39	18.77
	3	38.97	7.82	26.59
	4	21.08*	5.50	14.89

Note: "∗" suggests the optimal lag length with the lowest values of MAIC, MBIC, and MQIC. One lag is selected following MBIC.

statutory BBR states, and constitutional BBR states. The number of optimal lags for all the panel VAR models is determined using information criteria Bayesian (MBIC). The preferred model has the lowest values of information criteria. MBIC suggests that the optimal lag length is 1 for all the models considered (Table 3).

The panel VAR estimation results are presented in Table 4. Note that changes in business cycle variable (Δbusiness as it is nonstationary as well) are added to all four models. As discussed in the Data section, we selected the GDP-based recession indicator index from FRED Economic Data to represent the business cycle. This index measures the probability that the US economy was in a recession (Hamilton, 2022). Estimation results are consistent across models with different p-values. In all four models, tax revenues ($\Delta \ln$ rvn) in Table 4 have positive effects on state expenditures ($\Delta \ln$ exp) see $\Delta \ln$ exp equation), which implies tax revenues Granger cause expenditures. The relationship between state expenditures and tax revenues is consistent with Chang et al. (2002) Darrat (2008), Dritsaki (2018), and Siami-Namini et al. (2018). This result supports tax-and-spend, which indicates that adjustments in tax revenues lead to changes in state expenditures. Note that the lagged state expenditures are not associated with tax revenues, that is, not statistically significant. State expenditures in period $t-1$ do not have any effect on tax revenues in t (see $\Delta \ln$ rvn equation).

Estimated coefficients for the business cycle are worthy of discussion. As the larger value of GDP based recession indicator indicates that the US (has a higher chance to) experiences a recession. Thus Δbusiness> 0 implies that the US is moving toward a recession. A positive coefficient means that there are more state revenues and expenditures during the recession. The positive relationship between business cycles and tax revenues may be counter-intuitive

Table 4: Panel VAR Results

	All 48 States and D.C.	Weak BBR	Statutory BBR	Constitutional BBR
$\Delta \ln \text{rvn}$ equation				
$\Delta \ln \text{rvn}_{t-1}$	0.087	-0.302	0.079	0.133^{+}
	(0.13)	(0.21)	(0.27)	(0.09)
$\Delta \ln \text{exp}_{t-1}$	-0.016	-0.028	-0.045	-0.003
	(0.02)	(0.08)	(0.08)	(0.02)
Δbusiness	0.015^{+}	0.006	0.072^{+}	0.006
	(0.01)	(0.01)	(0.05)	(0.01)
$\Delta \ln \text{exp}$ equation				
$\Delta \ln \text{rvn}_{t-1}$	0.432^{***}	0.557^{+}	0.215^{*}	0.641^{***}
	(0.09)	(0.35)	(0.11)	(0.15)
$\Delta \ln \text{exp}_{t-1}$	-0.328^{***}	-0.314^{**}	-0.312^{**}	-0.350^{***}
	(0.09)	(0.15)	(0.12)	(0.13)
Δbusiness	0.023^{***}	0.013	0.049^{*}	0.016^{*}
	(0.01)	(0.01)	(0.03)	(0.01)
N	686	126	98	462
Number of panels	49	9	7	33
No. of T	14	14	14	14

Note: Standard errors are in parentheses. The 1%, 5%, 10% and 15% levels of significance are given as ***, **, *, and $^{+}$, respectively.

even if the estimated coefficients are not statistically significant. It is because "total" tax revenues usually decline when the economy is in a recession; data show that individual and corporate income taxes and property taxes declined with the recession. The reason we have insignificant but positive coefficients in Table 4 is an intergovernmental transfer from federal government. When the US experienced the recession, especially from 2008 to 2009, there were substantial increases in intergovernmental transfers from federal. As a result, state tax "total" government revenues were not decreased; even tax revenues were increased in some states (see Figure 1). State expenditures have increased during the recession as shown in Table 4; significant positive estimates for Δbusiness in expenditure equations except for weak BBR states.

Even though we have some insights from the result in Table 4, especially short-term changes, it is challenging to interpret the magnitudes and direction of the impact of the series over time due to dynamic interrelationships among the variables. IRFs provide a better evaluation of the interrelationship between state expenditures and tax revenues. For the Cholesky decomposition to generate IRFs, the order of the variables should be determined. The Granger causality test is used to order the variables.

Table 5: Panel VAR-Granger Causality Wald Test

		χ^2	df	Prob > χ^2
All 48 States & D.C.	$\Delta \ln \text{rvn} \rightarrow \Delta \ln \text{exp}$	0.72	1	0.40
	$\Delta \ln \text{rvn} \leftarrow \Delta \ln \text{exp}$	22.04	1	0.00
Weak BBR States	$\Delta \ln \text{rvn} \rightarrow \Delta \ln \text{exp}$	0.13	1	0.72
	$\Delta \ln \text{rvn} \leftarrow \Delta \ln \text{exp}$	2.55	1	0.11
Statutory BBR States	$\Delta \ln \text{rvn} \rightarrow \Delta \ln \text{exp}$	0.33	1	0.57
	$\Delta \ln \text{rvn} \leftarrow \Delta \ln \text{exp}$	3.75	1	0.05
Constitutional BBR States	$\Delta \ln \text{rvn} \rightarrow \Delta \ln \text{exp}$	0.04	1	0.85
	$\Delta \ln \text{rvn} \leftarrow \Delta \ln \text{exp}$	19.10	1	0.00

5.3. Granger Causality Test

Granger causality test (Granger, 1969) is used to examine the causal relationships. The null hypothesis is

$$b_{i,1} = \cdots = b_{i,k} = 0 \tag{6}$$

where $b_{i,k}$ is the estimated coefficients in equation (5), i represents variables and k is the optimal lag. Granger causality test shows there is an unidirectional causality from $\Delta \ln \text{rvn}$ to $\Delta \ln \text{exp}$, not vice versa (Table 5). Note that the Granger causality test does not tell the contemporaneous causal relationship between $\Delta \ln \text{rvn}$ and $\Delta \ln \text{exp}$. It is the causality of the lagged variable to the current variable. Even so, the order of variables to generate IRFs is tax revenues and state expenditures, assuming that Granger causality is valid for the contemporaneous causal relationship as well. As shown in Table 5, as expected, tax revenues Granger cause government expenditures in all four models. For the weak BBR states, however, the p-value is 11% larger than the conventional p-value in the literature. We may conclude that fiscal synchronization (bidirectional causality) might hold for the weak BBR states, at least, we fail to reject the hypothesis with the conventional p-value.

5.4. Impulse Response Functions

Figure 2 presents IRFs for model 1 (48 states and D.C.), with an ordering with $\Delta \ln \text{rvn}$ and $\Delta \ln \text{exp}$. As discussed earlier, IRFs visualize the impact of one variable while keeping all other variables constant. More specifically, each one of the tax revenues and state expenditures in the system takes a shock of one standard deviation of its innovation with keeping the other innovations constant. Each IRF in Figure 2 shows how (changes in) tax revenues or (changes in) state expenditures respond to the shock to (changes in) tax revenues and (changes in) state expenditures, respectively. The vertical axis indicates the size and direction of the impact from the shock. The horizontal axis represents the years that elapsed after the shock. The shaded areas in Figure 2 represent 95% confidence bands for responses variables from 1,000 Monte Carlo simulations following Love and Zicchino (2006)

As shown in Figure 2, (changes in) tax revenues have a positive impact on (changes in) state expenditures (Panel Δln rvn $\rightarrow$ Δln exp), and these are statistically significant, that is, the increase in tax revenues increases state expenditures. However, as presented in

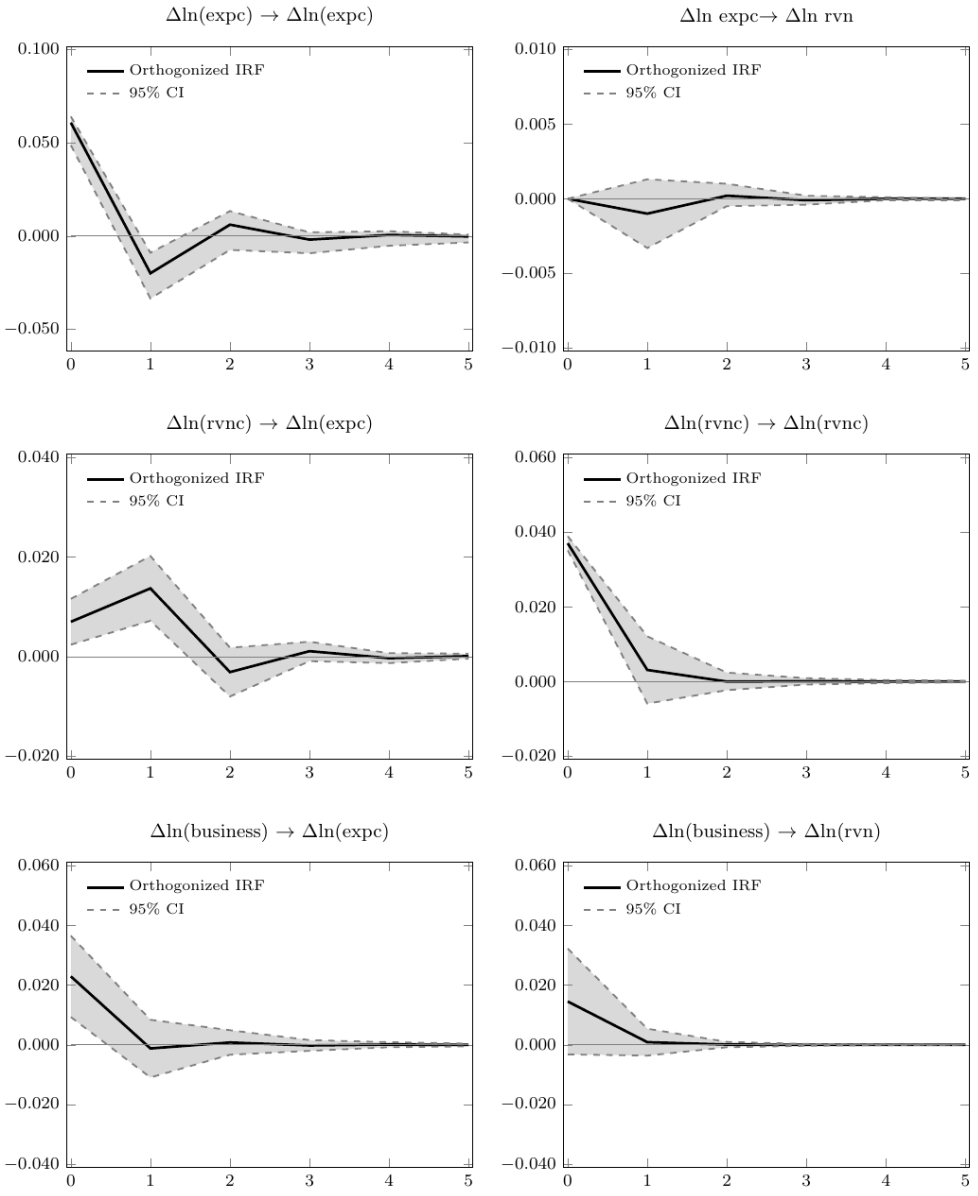


Figure 2: IRFs for All 48 US States and Washington DC (except ND and WY)

Notes: Every column presents the different shocks to change in government expenditure per capita, Δln exp, and change in tax revenue per capita, Δln rvn, i.e., impulse → response.

Figure 2, the effect of state expenditures on tax revenues (Panel Δln exp → Δln rvn) is not significant. We may conclude that state expenditures do not change tax revenues. IRFs for other models, that is, for weak BBR states, statutory BBR states, and constitutional BBR states (not reported here to save space and available upon request), look similar with slightly different magnitudes. Interpretation of IRFs for other models wouldn't be different. (Changes in) the business cycle has positive and statistically significant impacts on state expenditures (Panel Δbusiness → Δln exp). Positive changes in the business cycle imply

that the economy moves toward the recession, which causes more expenditure in the state. Tax revenues are also positively related but not statistically significant (Panel Δbusiness $\rightarrow$ Δln rvn).

6. SUMMARY AND POLICY IMPLICATIONS

Tax revenues and state expenditures are the core of fiscal policy and are essential in correcting the fiscal imbalances to achieve BBRs. BBRs obligate states to balance spending with projected revenues, even though there is flexibility in achieving the requirement. The relationship between these two variables has been debated in many previous studies but no consensus. Four hypotheses have been suggested: tax-and-spend (tax causes expenditure), spend-and-tax (expenditure causes tax), fiscal synchronization (bidirectional causality), and institutional separation (both are independent).

This study attempts to examine which hypothesis is valid for US states with BBRs using the panel VAR model. Data are compiled from Urban-Brookings Tax Policy Center for the period of 2004-2020. The empirical results are reported in Table 4 (panel VAR estimation) and Figure 2 (impulse response functions) show that tax revenues have a positive impact on state expenditures and support the tax-and-spend hypothesis. It is consistent with findings in Kazungu (2019), Lojanica (2015), Reddick (2002), Saunoris and E (2010), Saunoris (2013), and Zapf and Panye (2009). We also split the samples into three different groups, weak BBR, statutory BBR, and constitutional BBR, following the classification of Tax Policy Center (2020b) to get more insight. The results for the three groups support the tax-and-spend hypothesis. Interestingly, fiscal synchronization (bidirectional causality) might hold for the weak BBR states, at least, we fail to reject the hypothesis with the conventional p-value. Empirical results tell us that adjusting taxes will change expenditures in the US states, for example, cutting taxes reduces states' expenditures. Raising taxes is unavoidable for more state expenditures. As BBRs are about planning, tax revenues make states plan on how to spend them. Considering BBRs with the empirical results from this study states expenditures should be adjusted close to (projected) tax revenues.

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APPENDIX

Table A1: Summary of Previous Studies

Study	Study Region	Period	Method
	revenue → expenditure		
Blackley (1986)	U.S. federal government	1929-1982	VAR & Granger causality test, & Sims LDV tests with GNP
Marlow and Manage (1987)	U.S. states and local governments	1952-1982	Bivariate VAR for individual state or local governments with Granger causality test
Marlow and Manage (1988)	U.S.	1952-1982	Bivariate VAR & Granger test
Owoye (1995)	Japan and Italy	1961-1990	Bivariate VECM & Engle-Granger cointegration
Payne (1998)	24 U.S. states	1942-1992	Engle-Granger & VECM
Hondroyiannis and Papapetrou (2001)	Greece	1975-1993	VAR & Granger causality test
Chang et al. (2002)	Japan, South Korea, Taiwan, the UK, and U.S.	1951-1996	VAR & Granger causality test
Darrat (2008)	Lebanon and Tunisia	1985-1997	VECM with real GDP and interest rate & Granger test
Dritsaki (2018)	Greece	1980-2015	ARDL bounds testing & Toda-Yamamoto Causality Test.
Karlsson (2019)	China	1980Q1–2015Q4	Toda-Yamamoto causality test
	revenue ← expenditure		
Anderson et al. (1986)	U.S. Federal government	1946-1983	VAR with control variables & Granger causality test
von Furstenberg et al. (1986)	U.S.	1954Q1-1982Q4	VAR
Jones and Joulfaian (1991)	U.S.	1972-1986	VECM & Engle-granger cointegration tests
Reddick (2002)	Canada, the UK, and the US	1950-2000	VAR
Chang et al. (2002)	Australia and South Africa	1951-1996	VAR & Granger causality test
Zapf and Panye (2009)	U.S. aggregate state and local governments receipts and expenditures	1959-2005	Threshold autoregressive and momentum threshold autoregressive cointegration framework
Saunoris and E (2010)	the UK	1955-2009	Threshold autoregressive and Momentum threshold autoregressive
Lojanica (2015)	Serbia	2003M1-2014M11	ARDL, VECM and Ganger causality

Summary of Previous Studies, Cont'd.

Study	Study Region	Period	Method
Siami-Namini et al. (2018)	Washington, D.C.	1984-2015	Bivariate VECM & Granger causality
Kazungu (2019)	Tanzania	2000-2017	VAR
	revenue ↔ expenditure		
Miller and Russek (1990)	U.S.	1946Q1-1987Q2	Bivariate VECM & Engle-Granger cointegration
Owoye (1995)	Canada, France, Germany, the UK, & U.S.	1961-1990	Bivariate VECM & Engle-Granger cointegration
Hasan and Lincoln (1995)	the UK	1961M1-1993M3	Cointegration & Granger-Akaike's synthesis of modelling
Chang et al. (2002)	Canada	1951-1996	VAR & Granger causality test
Vamvoukas (2012)	EMU	1970-2006	Panel data, Generalized two-stage least squares & Generalized method of moments
Irandoust (2018)	Sweden	1722–2011	Hidden cointegration techniqu & Granger causality test
	mixed results		
Payne (1998)	U.S. States	1942-1992	Engle-Granger & VECM
Chang et al. (2002)	South Korea, Taiwan, Thailand, Australia, Canada, Japan, New Zealand, South Africa, the UK, and U.S.	1951-1996	VAR & Granger causality test
	no causality		
Manage and Marlow (1986)	U.S.	1929-1982(except 1941-1944)	VAR & Granger causality
Baghestani and McNown (1994)	U.S. federal government	1951M1-1998M4	Bivariate VECM & Granger causality
Mendoza et al. (1997)	G7 and 11 countries	1965-1991	Cross country panel regression
Chang et al. (2002)	New Zealand and Thailand	1951-1996	Granger causality test