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Saving for a rainy day: Estimating the needed size of U.S. state budget stabilization funds

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ABSTRACT

Rainy day funds (RDFs) are potentially an important countercyclical tool for states to stabilize their budgets and the overall economy during economic downturns. However, how much each state needs to save in its RDF has become an increasingly important yet unresolved policy question. To address this issue, this paper develops some potential target RDF levels for each U.S. state, based on both the estimated short-term revenue component associated with business cycles and the extent of states' preferences for stable tax rates and expenditure. The analysis shows that, in the last 25 years, at least 21 states never saved enough in their RDFs to offset revenue shortfalls from trend for each downturn period. The paper also provides policy recommendations on reforming the RDF caps.

1. Introduction

State revenue is cyclical. It rises during economic booms and declines during economic downturns because tax bases (for example, personal and corporate income, and sales) move procyclically. Recent studies find that states' revenue cyclicality has increased since 2000 (McGranahan and Mattoon, 2012a; Kodrzycki, 2014). However, the demand for many categories of public services is not elastic to the condition of the economy.[1] Mattoon (2003) observes that Medicaid and education expenses spiked in the aftermath of the 2001 recession. As a result, states face budget shortfalls in downturn years. Unlike the federal government, states must resolve these budget shortfalls under the balanced budget requirements that face every U.S. state except Vermont.[2]

States have limited options to address budget shortfalls in the short term.[3] First, they may cut spending and/or raise tax rates. These are procyclical policies that not only disrupt public services and increase taxpayers' burden but also worsen recessions and slow economic recoveries. Raising tax rates has also become increasingly difficult, if not impossible, because of tax limitations and political pressures. States are found to have been less willing to increase tax rates to cope with recessions since 2000 (McGranahan and Mattoon, 2012a). Second, states may issue more debt. However, state laws often prohibit states from borrowing to fill operating budget deficits (Vasche and Williams, 1987). States may also face self-imposed debt limits and higher borrowing costs because credit rating agencies often downgrade states' credit quality during recessions. Third, states may withdraw savings, if any, that have accumulated during good economic times. This is a countercyclical policy that helps to stabilize both the state budget and the economy during economic downturns. It can preserve social programs, which particularly benefit low-income families who become more vulnerable when economic times are hard.

Rainy day funds (RDFs), formally known as budget stabilization funds, are an institutionalized form of state savings. Created by state legislation, RDFs consist of money that is deposited during economic booms and withdrawn during economic downturns (including officially

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[1] Zhao and Coyne (2013) find that the income elasticity of state and local spending on education and social services and income maintenance—the two largest spending categories of the state and local government sector—is less than one.

[2] Cornia and Nelson (2003) also suggest that policymakers must balance their budgets even during a difficult economic time in order to safeguard their political prospects.

[3] In the longer term, states could possibly implement structural tax reforms and adopt more stable tax bases to reduce cyclical influences on state revenue in the future. For example, some suggested that states consider reducing reliance on the volatile personal income taxes, especially capital gains taxes and shifting to consumption-based taxes. However, Kodrzycki (2014) points out that such a change would decrease the progressivity of tax payments and reduce revenue adequacy due to the erosion of sales tax base. More importantly, it does not eliminate the need for RDF because even relatively stable tax bases still fluctuate with business cycles. Therefore, her paper concludes that tax reforms are unlikely to emerge as the preferred policy change to address budget stability issues.

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declared recessions) to smooth state revenue and the state budget over business cycles, which tend to be longer than the annual or biennial state budget cycles (Hou, 2005).[4] RDFs allow states to make timely and rational budget decisions, rather than shortsighted decisions in response to fiscal crises (Cornia and Nelson, 2003). They have been shown to promote state savings and help to ease states' fiscal stress during past recessions, although they often do not completely eliminate the fiscal stress (for example, Knight and Levinson, 1999; Sobel and Holcombe, 1996b; Douglas and Gaddie, 2002; Wagner and Elder, 2005, 2007; Hou, 2005, 2006).[5]

Various policy groups, regardless of their political affiliations, recommend establishing an RDF as a sound financial management technique (Henchman, 2012, 2013; McNichol and Boadi, 2011; NASBO, 2013; Pew Charitable Trusts, 2014). All but five states (Arkansas, Colorado, Illinois, Kansas, and Montana) have adopted RDFs since 1945 (McNichol and Boadi, 2011). The nationwide RDF balance in FY 2012 was $34 billion, equal to 2 percent of the total of all 50 states' general expenditure.

The magnitude of RDFs is an important characteristic that affects their costs and benefits.[6] On the one hand, RDFs with low reserves may not be effective in stabilizing the state budget. Policy groups across the political spectrum agree that states had insufficient reserves in RDFs for the 2001 and 2007–2009 recessions and would benefit from having larger RDFs in the future (Henchman, 2012, 2013; McNichol and Boadi, 2011; NASBO, 2013; Pew Charitable Trusts, 2014). On the other hand, maintaining a large RDF incurs opportunity costs and may create moral hazard for policymakers. RDF reserves are usually invested in cash-like, low-yield assets, which could otherwise be used for tax cuts or to fund more public services (Garrett, 2013). Policymakers may be less careful about expenditure planning when having a large RDF, because they may assume that the money in the RDF will be available for them to fund whatever expenditure programs they may enact (Cornia and Nelson, 2003).

It has been unclear in both academic and policy circles how much each state should save in its RDF. This paper seeks to fill some of this gap by determining the needed size of each state's RDF. To do so, we follow the principle suggested by Gold (1995) that the needed RDF size should depend upon both the volatility of each state's revenues and the desirability of having stable tax rates and expenditure growth. We use the past 25 years of data on state revenue and various methods to estimate for each state the short-term revenue component associated with business cycles.[7] We then calculate the amount of the "needed RDF" over each "fiscally stressed" period when revenues have fallen below their long-term trend. Next, we illustrate how states can choose a target RDF level from the distribution of these needed RDFs, depending upon the extent of their preference for stable tax rates and spending.

This paper contributes to the literature and policy debates in several ways. First, we use new methods, including an income-based approach, a quartic time model, and filtering, to estimate the short-term component of state revenue associated with business cycles. We recommend against using the linear time model commonly used in previous research, because, as we show, it has serious flaws. Second, we compute the short-term component of revenue after removing the impact of new policy changes on state revenue. Without this adjustment, previous research suffers a downward bias in estimating the absolute size of the short-term revenue component. Third, this paper covers each of the 50 states and the United States as a whole, whereas previous studies tend to focus on a single state (for example, Vasche and Williams, 1987; Navin and Navin, 1997; Sjoquist, 1998; Kriz, 2002, and University of Tennessee Center for Business and Economic Research, 2007). Fourth, in order to increase policy relevance we provide state policymakers with a set of choices on potential target RDF size depending upon the extent of their preferences for fiscal stability. Finally, we examine the degree to which state-imposed caps on RDF size and actual RDF balances have been sufficient relative to the need in the past and further provide policy recommendations on reforming state RDF caps.

2. Rules of thumb

Several influential policy organizations have proposed a rule of thumb on the size of state RDFs in the last 30 years. The Fiscal Affairs and Oversight Committee of the National Conference of State Legislatures recommends that RDFs equal 5 percent of annual general fund expenditure (Yondorf, 1983). The Government Finance Officers Association (GFOA) suggests a larger RDF—equivalent to two months of regular general fund operating revenue or expenditure, which is about 16.7 percent of annual operating revenue or expenditure (GFOA, 2009). Similarly, the Center on Budget and Policy Priorities advocates RDFs of 15 percent of annual general fund operating expenditure (McNichol and Boadi, 2011).

These rules of thumb, especially the 5-percent rule, have been cited widely by policymakers and have influenced state RDF policies (Gramlich, 2011). For example, in early 2014 the Massachusetts Undersecretary of Administration and Finance emphasized that the state needed to continue to rebuild its RDF because "the reserve is not yet at the healthier amount of 5 percent of revenues" (Metzger, 2014). In addition, 37 states set a cap on their RDFs at 15 percent of their general fund revenue or expenditure or lower (McNichol and Boadi, 2011). Among them, 12 states put the cap at exactly 5 percent and four states put the cap at exactly 15 percent.

These rules of thumb have been criticized for two main reasons. First, they are viewed as arbitrary and lack the support of scientific evidence (Gramlich, 2011; Joyce, 2001). Second, they are essentially a "one-size-fits-all" approach, which ignores the fact that states have different degrees of revenue volatility and different levels of desire for stable tax rates and expenditure growth (Gold, 1995).

3. Data

This paper uses a newly constructed dataset to estimate a needed size of the rainy day fund for each of the 50 states. Because not only economic factors but also changes in state policy can affect state revenue, we need to remove the impact of policy changes on state revenue as much as data allow.

We rely on two data sources. First, the Census Bureau's Annual Survey of State Government Finances provides comprehensive information on state revenues that is relatively comparable both across states and within states over time. We focus on each state's own-source general revenue,[8] which includes all state taxes (with small adjust-

[4] For example, Maine Revised Statute Title 5, Chapter 142 states that "amounts in the stabilization fund may be expended only to offset a General Fund revenue shortfall." Similarly, Rhode Island General Laws 35-3-20 specifies that "a state budget reserve and cash stabilization account...shall be used solely for the purpose of providing such sums as may be appropriated to fund any unanticipated general revenue deficit caused by a general revenue shortfall."

[5] Other studies find that having an RDF also helps states to circumvent tax and expenditure limitations (Wagner and Sobel, 2006), increase pension contributions (St. Clair, 2013), reduce bond yields (Wagner, 2004), and increase credit ratings (Grizzle, 2010), although Marlowe (2011) finds little evidence of the effect of reserve funds on credit quality.

[6] The deposit rule, the withdrawal rule, the replenishment rule, and other RDF features also influence the effectiveness of RDFs (see Sobel and Holcombe (1996b); Hou (2004 Wagner and Elder (2005)).

[7] This paper focuses on revenue cyclicality because the statutory mandate for RDF in many states is merely to address revenue shortfalls (see Footnote 4). Business cycles could also affect state expenditure, as the caseload of public welfare and other social services may increase with the unemployment rate (McGuire and Merriman, 2006). Future research could explore incorporating considerations of expenditure cyclicality.

[8] Following previous studies (for example, Sobel and Holcombe, 1996b; Navin and

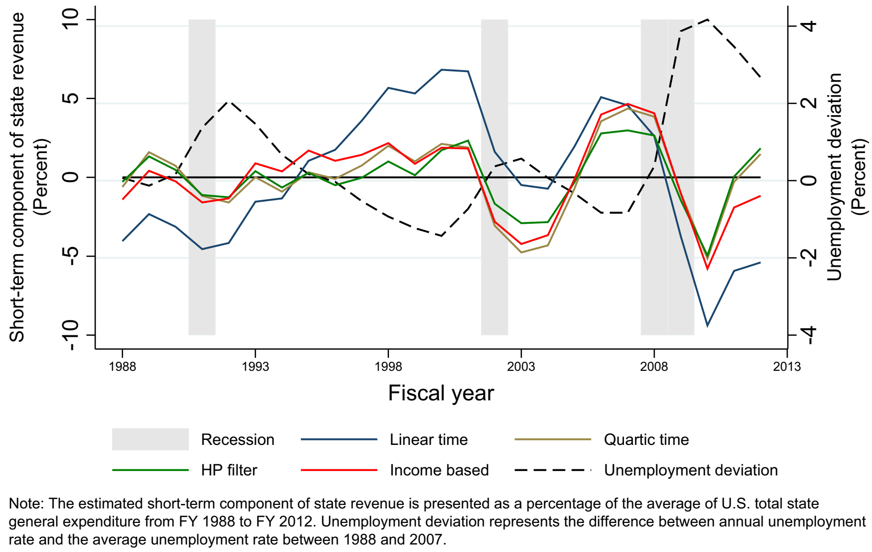


Fig. 1. Estimated short-term component of state revenue for the United States.

ments for several states),[9] current charges, and miscellaneous revenues. The latest data available from this survey at the time of analysis are for FY 2012.

The second data source is the National Association of State Budget Officers (NASBO)'s annual Fiscal Survey of States. Starting from FY 1988, this survey has reported each state's estimated annual revenue changes due to newly enacted policy actions in each year, such as an increase (or decrease) in the income or sales tax rate. We use the NASBO data to adjust the Census Bureau data in order to remove the impact of new policy changes on state revenue. If NASBO reported a revenue gain for a state due to newly enacted policy actions, we deduct that increase amount from the Census Bureau-reported own-source general revenue of that state. If NASBO reported a revenue loss for a state due to newly enacted policy actions, we add back the decrease amount.

This adjusted revenue is less than an ideal measure, which is what each state would have collected in each year if the state had never changed its tax policy since FY 1988. In reality, the NASBO survey or any other known survey does not ask about revenue changes resulting from policy actions enacted in previous years, likely because most states do not estimate it. Like previous researchers, we do not have suitable data and a reliable method to remove the impact of all the policy changes since FY 1988 on each year's state revenue.

That said, this paper still makes an important improvement upon previous research by at least partially removing the impact of policy changes on state revenue. Previous research does not make such an adjustment for policy changes. Therefore, previous estimates of the absolute size of the short-term revenue component likely suffer a downward bias, for states tend to increase tax rates or impose higher fees and charges to counteract revenue shortfalls during recessions, masking the true impact of the economic downturn (Maag and Merriman, 2003). Using the U.S. as a whole as an example, Appendix Fig. A1 shows that while using the same linear time model (which is one of the estimation methods we use in the next section), the absolute size of the estimated short-term component based on the unadjusted state revenue is consistently smaller than the one based on our adjusted state revenue measure,

We have both the Census Bureau data and the NASBO data between FY 1988 and FY 2012. Thus, we can calculate each state's adjusted own-source general revenue in each of the past 25 years (all inflated to the 2012 dollar amounts).[10] This time span covers three national recessions: the 1990–1991 recession, the 2001 recession, and the 2007–2009 Great Recession. Owyang et al. (2005) show that state-level recessions have often not been in sync with national recessions. States have entered recessions long before or long after national recessions. They also have experienced state-specific recessions that were unrelated to a national recession. Therefore, the number and timing of business cycles for individual states may differ from the national experience over our sample period.

(*footnote continued*)
Navin, 1997; Cornia and Nelson, 2003, University of Tennessee Center for Business and Economic Research, 2007), we exclude intergovernmental revenue, which is mostly in the form of federal grants, for several reasons. First, federal grants, especially Medicaid matching grants, are distributed mainly for addressing state expenditure cyclicality, while this paper focuses on revenue cyclicality. Second, it is expected that the federal government will significantly cut grants to states and localities in the process of addressing large federal deficits in the long run (Chernick et al., 2012). These expected cuts mean that the historical pattern of federal grant distributions may not be able to indicate the future pattern of federal grant distributions. Therefore, it is more plausible and prudent for researchers and states to design an RDF policy that does not rely on federal grants. Third, with the implementation of the Affordable Care Act and the following repeal efforts in the Congress as well as the chronically underfunded federal highway fund, there is great uncertainty on how federal grants to states will be allocated in the future. Fourth, the timing of federal grant distributions may not match the timing of states' revenue need, because there is often a time lag in federal assistance to state governments. For example, the federal government did not provide significant fiscal relieves to states during the 2001 recession until it passed the Jobs and Growth Tax Relief Reconciliation Act of 2003, two years after the recession. Because of this lag, some states appeared to have total revenue (including federal grants) above trend in 2003 and 2004 when they received additional federal assistance; we do not want to misinterpret it as a result of the economic boom for these states.

[9] We exclude state property tax figures for nine states. We drop Arizona's state property tax because the Census Bureau failed to take account of all of this tax before FY 2006, thereby producing an inconsistent series. Six states, Arkansas, Michigan, Minnesota, Montana, New Hampshire, and Vermont, adopted a state property tax for funding local public schools starting in the 1990s or 2000s. For this study, these property taxes are not considered as state own-source revenue, because these states simply relabeled an essentially local tax as a state tax for redistributive purposes. Florida and North Carolina eliminated an intangible personal property tax in the late 1990s, causing a sharp decline in the state property tax in those years. We exclude these states' property tax so as not to misinterpret as cyclical the associated revenue changes due to policy changes. In addition, we exclude New Hampshire's other selective sales tax, which includes its Medicaid Enhancement Tax. The state created this tax in the early 1990s with the purpose of extracting more Medicaid reimbursement from the federal government. This tax is thus essentially a federal revenue transfer, and does not constitute state own-source revenue.

[10] Connecticut adopted a broadly based personal income tax in FY 1992. This caused a large systematic change in state revenue, which cannot be fully adjusted by using the NASBO data. Therefore, we calculate the Connecticut adjusted own-source general revenue only for FY 1993–FY 2012.

4. Methodologies for estimating the short-term revenue component

This paper applies several new methodologies in addition to the traditional linear time model to estimate the short-term component of state revenue associated with business cycles. We assume that each state's adjusted own-source general revenue is a combination of a long-term component and a short-term component associated with business cycles, neither of which is directly observable to researchers.[11] The short-term component of state revenue associated with business cycles is therefore derived as the difference between the adjusted state own-source general revenue and its long-term component. The long-term and short-term components are assumed to have different underlying operating determinants (Kuznets and Jenks, 1961).

4.1. Method assuming a specific operating determinant

We first offer an economic model based on an assumed underlying operating determinant. Following Ladd and Yinger (1989), we assume that personal income is the ultimate tax base for states, because taxes, fees, and charges are ultimately paid out of taxpayers' income.[12] In other words, personal income is considered the ultimate principal source of state revenue, regardless of the mix of revenue-raising vehicles states actually used (for example, income tax versus sales tax). Therefore, the adjusted state own-source general revenue can be modeled as a function of the state's personal income:

$$y_t = f(x_t) + \varepsilon_t,$$

where y_t is the total amount of adjusted state own-source general revenue in year t, x_t is total personal income in year t, both y_t and x_t are expressed in 2012 dollars, ε_t is a stochastic error term with a mean of zero, and $t=1, 2, 3, ., T$. The functional form $f(.)$ may vary from state to state, and it may be linear or nonlinear. Therefore,

$$f(x_t) = \beta_0 + \beta_1 x_t \quad \text{or} \quad f(x_t) = \beta_0 + \beta_1 x_t + \beta_2 x_t^2.$$

Appendix Table A1 shows the selected functional form $f(.)$ and estimated coefficients for each state.[13]

Next, we assume that the long-term component of state revenue, τ_t, is determined by the long-term component of personal income, x_t^τ, and that the relationship between the two follows the same functional form, $f(.)$. Therefore,

$$\hat{\tau}_t = f(\hat{x}_t^\tau),$$

where $\hat{x}_t^\tau$ is the estimated long-term component of personal income in year t, which can be extracted from the data on personal income using other statistical approaches.[14]

[11] There is an established literature that distinguishes the short-term behavior of state revenue from the long-term behavior of state revenue (for example, Dye and McGuire, 1991; Sobel and Holcombe, 1996a, and Bruce et al., 2006).

[12] An Engle-Granger cointegration test shows that personal income and adjusted state own-source general revenue are cointegrated for all states except California, Michigan, North Dakota, Oklahoma, and Texas. Personal income and adjusted state own-source general revenue are not cointegrated for the last three states, likely because these states rely on severance taxes on energy resources as a major revenue source.

[13] To determine the functional form $f(.)$ for each state, we first run a quadratic polynomial model of personal income for each of the 50 states. The quadratic term turns out to be statistically significant at the 10 percent level for 21 states. Thus, we keep the quadratic polynomial model for these 21 states. Among the other 29 states, 22 have not only an insignificant quadratic term but also an insignificant linear term, due to model misspecification. Next, we run a linear model for these 29 states. The linear term in this model becomes statistically significant and positive except for Alaska. Therefore, we use the linear model for these 28 states. We choose the quadratic polynomial model for Alaska because its adjusted R-squared is slightly higher. It should be noted that a positive coefficient on the quadratic term does not necessarily suggest income tax progressivity.

[14] In this paper, we extract $\hat{x}_t^\tau$ from annual personal income using a Hodrick-Prescott filter, which we explain more in the next sub-section. We also tried the Christiano-Fitzgerald (CF) filter, which gives almost identical results. By using a filter, this income-

Table 1
Maximum of the needed RDFs during FY 1988 — FY 2012. (as a percentage of state general expenditure).
Source: Author's calculations.

State	Linear time	Income based	Quartic time	HP filter
AK	171.0	139.0	89.5	40.6
NJ	33.4	25.9	18.4	14.1
NM	31.9	15.7	21.2	12.9
CT	24.8	19.6	16.7	11.9
NV	71.3	27.9	21.7	11.8
KS	43.8	34.2	24.2	11.5
MI	72.8	21.7	13.1	11.3
CA	44.9	15.3	13.5	11.2
AZ	36.1	19.6	16.4	11.1
HI	22.8	15.7	13.4	10.6
ID	71.3	14.2	15.3	10.5
IN	25.4	52.1	15.5	10.4
TN	25.2	40.5	17.1	10.2
MA	38.4	13.3	16.9	10.2
PA	43.9	14.7	12.0	10.2
WY	111.0	17.9	17.8	10.1
MO	62.9	17.2	14.1	10.0
NY	17.2	24.3	16.8	9.5
UT	42.3	15.3	13.9	9.4
CO	47.3	14.8	15.1	9.4
ND	119.0	42.9	13.8	9.2
IL	32.8	11.0	9.3	9.0
OR	66.1	16.1	15.9	8.9
MN	58.3	14.7	14.7	8.7
MS	52.6	16.8	9.9	8.4
LA	33.1	33.3	10.9	8.3
DE	57.0	17.0	14.1	8.0
MD	18.9	12.1	9.6	7.9
GA	79.2	24.9	11.6	7.9
FL	48.0	17.7	10.3	7.8
RI	19.7	9.5	6.2	7.8
NC	43.7	12.7	14.5	7.7
WI	45.3	18.1	10.4	7.4
ME	46.1	15.8	11.4	6.9
VA	35.3	8.9	10.1	6.9
TX	33.6	9.5	10.1	6.8
WV	18.3	52.0	8.5	6.2
OK	12.1	6.4	7.2	6.1
MT	13.8	10.6	10.7	5.8
AR	36.2	6.6	10.8	5.8
AL	22.7	8.8	9.6	5.7
NH	22.3	20.3	6.7	5.7
SC	26.4	10.7	11.2	5.5
OH	33.1	46.1	9.9	5.4
WA	44.1	8.7	10.6	5.1
NE	44.9	10.0	7.7	4.8
IA	21.3	7.6	5.9	4.3
VT	18.4	26.9	5.6	4.3
SD	16.8	5.4	6.5	3.8
KY	49.6	9.9	6.4	3.2
US	34.0	9.7	11.6	6.9
50-state average	44.1	21.4	14.1	8.9

Note: The 50-state average is an arithmetic average of the maximum needed RDF of the 50 states.

This income-based method has some drawbacks. First, it is likely that there are additional underlying operating determinants of state revenue besides personal income. For example, energy prices significantly affect energy-producing states' revenue. These are not fully reflected in these states' personal income, because some workers in these states work outside the energy sector, and residents of other states and countries share the profits of energy firms (for example, through dividends).[15] Second, this

(*footnote continued*)
based method implicitly acknowledges the validity of other statistical approaches to separating the long-term component from the data.

[15] One may also argue that personal income is not a good proxy for sales tax base. This could potentially result in more estimation errors for states that have sales tax but no income tax than for states with income tax.

Table 2
Median of the needed RDFs during FY 1988 — FY 2012. (as a percentage of state general expenditure).
Source: Author's calculations.

State	Linear time	Income based	Quartic time	HP filter
AK	11.8	14.2	50.6	16.2
NV	37.6	9.1	12.7	9.5
CT	16.2	9.5	10.8	8.4
AZ	29.7	6.6	10.2	7.6
NC	20.6	10.0	10.0	7.2
FL	35.3	7.2	9.0	6.9
MN	27.7	11.7	4.0	6.4
GA	58.4	12.0	7.2	6.2
HI	22.4	11.4	7.6	5.9
WY	0.7	9.0	5.9	5.7
UT	26.9	7.0	7.5	5.6
MA	23.3	11.7	4.9	5.5
TX	16.0	7.5	6.3	5.4
CA	28.8	5.5	10.0	5.4
IL	22.3	3.0	5.2	5.1
OR	25.6	6.2	4.5	5.0
NJ	12.7	13.3	6.0	4.8
TN	22.6	6.7	11.9	4.7
ME	36.4	3.8	5.9	4.5
NE	36.7	4.1	5.4	4.5
CO	13.7	3.1	5.2	4.1
RI	18.4	4.7	4.4	4.0
PA	20.5	5.2	3.1	4.0
WI	34.4	4.1	2.3	3.9
NM	18.0	10.5	8.7	3.8
OK	3.4	5.6	5.6	3.7
OH	21.3	4.2	3.6	3.7
DE	21.8	10.1	3.1	3.7
MO	45.8	6.9	6.9	3.6
KS	18.8	8.5	21.3	3.5
VA	29.2	5.4	3.4	3.4
WV	9.7	5.8	4.1	3.4
LA	19.9	19.1	2.8	3.2
MI	54.5	14.9	6.0	3.2
MT	5.0	4.2	3.7	3.0
ID	31.6	3.2	7.5	2.9
MS	15.5	4.9	1.5	2.9
IN	12.6	3.9	3.5	2.9
SC	14.7	7.5	2.4	2.5
MD	6.2	2.6	3.4	2.4
WA	21.1	2.5	8.1	2.3
VT	10.8	1.3	2.5	2.2
AR	16.5	3.7	1.8	2.2
NY	6.3	7.4	8.1	2.1
IA	9.8	3.8	3.2	2.0
KY	36.4	4.6	3.4	1.9
AL	7.6	1.8	2.0	1.8
ND	59.9	2.4	5.1	1.7
NH	12.0	15.0	2.1	1.7
SD	2.1	1.3	1.4	1.6
US	20.8	6.6	2.5	2.1
50-state average	22.2	6.9	6.7	4.4

Note: The 50-state average is an arithmetic average of the median needed RDF of the 50 states.

method ignores tax exporting. Nonresidents may pay a large share of a state's taxes, fees, and/or charges if the state has a high concentration of tourism, gambling, or other industries that cater to out-of-state visitors. In addition, there is a measurement issue in the personal income data. The measure of personal income produced by the Bureau of Economic Analysis does not include capital gains. Some states rely on a capital gains tax more than others. For these reasons, the income-based method does not work well for a number of states. For example, energy-producing states, such as Alaska and Louisiana, and states that are heavily dependent on capital gains tax or spending from out-of-state visitors, such as Connecticut and Hawaii, have an adjusted R-squared value below 0.6 (see Appendix Table A1).

Table 3
Comparing state RDF caps with the median and maximum needed RDFs.
Source: McNichol and Boadi (2011), author's calculations.

State	RDF cap relative to general fund revenue or expenditure	RDF cap relative to general expenditure	Median needed RDF	Maximum needed RDF
NV	20.0	6.8	9.5	11.8
MA	15.0	10.7,	5.5	10.2
GA	15.0	8.5	6.2	7.9
VA	15.0	7.1	3.4	6.9
OK	15.0	6.3	3.7	6.1
OR	12.5	4.6	5.0	8.9
ME	12.0	5.6	4.5	6.9
CT	10.0	7.6	8.4	11.9
HI	10.0	6.1	5.9	10.6
TX	10.0	5.4	5.4	6.8
WA	10.0	4.8	2.3	5.1
IA	10.0	4.3	2.0	4.3
FL	10.0	4.3	6.9	7.8
WV	10.0	4.1	3.4	6.2
AL	10.0	3.7	1.8	5.7
SD	10.0	3.5	1.6	3.8
ND	10.0	3.3	1.7	9.2
NH	10.0	3.0	1.7	5.7
MI	10.0	2.6	3.2	11.3
NC	8.0	4.0	7.2	7.7
MD	7.5	4.0	2.4	7.9
MO	7.5	3.1	3.6	10.0
MS	7.5	2.6	2.9	8.4
IN	7.0	3.4	2.9	10.4
AZ	7.0	2.8	7.6	11.1
UT	6.0	2.6	5.6	9.4
NJ	5.0	3.3	4.8	14.1
DE	5.0	2.8	3.7	8.0
RI	5.0	2.7	4.0	7.8
OH	5.0	2.6	3.7	5.4
WI	5.0	2.6	3.9	7.4
CA	5.0	2.4	5.4	11.2
NY	5.0	2.3	2.1	9.5
KY	5.0	2.3	1.9	3.2
TN	5.0	2.2	4.7	10.2
ID	5.0	2.1	2.9	10.5
SC	5.0	1.8	2.5	5.5
VT	5.0	1.6	2.2	4.3
MN	4.0	2.3	6.4	8.7
LA	4.0	1.6	3.2	8.3
AK	–	–	16.2	40.6
WY	–	–	5.7	10.1
IL	–	–	5.1	9.0
NE	–	–	4.5	4.8
CO	–	–	4.1	9.4
PA	–	–	4.0	10.2
NM	–	–	3.8	12.9
KS	–	–	3.5	11.5
MT	–	–	3.0	5.8
AR	–	–	2.2	5.8

Note: Both the median and maximum needed RDF are calculated from the HP filter.

4.2. Methods without assuming specific operating determinants

There are two types of statistical methods that can be used to estimate the long-term component of state revenue without assuming specific underlying operating determinants. The first is to estimate state revenue using a parametric model of time, which assumes that the long-term component of state revenue follows a certain time trajectory. The other is to use filtering, a nonparametric smoothing technique that relies purely on the data to determine the shape of a smoothed curve.

4.2.1. Models of time

Previous research used a linear model of time to decompose state revenue into the long-term component (the so-called "trend") and the short-term component associated with business cycles (for example,

Table 4
The percentage of fiscally stressed periods with insufficient state savings. (FY 1988 — FY 2012).
Source: Author's calculations.

State	Number of fiscally stressed periods	Percentage of fiscally stressed periods with RDF balance < needed RDF	Percentage of fiscally stressed periods with (RDF balance+ general fund balance) < needed RDF
AL	5	100.0	100.0
AR	5	100.0	100.0
CA	5	100.0	100.0
CT	3	100.0	100.0
FL	5	100.0	100.0
LA	6	100.0	83.3
NY	6	100.0	83.3
PA	5	100.0	80.0
TN	5	100.0	80.0
VA	5	100.0	80.0
IL	4	100.0	75.0
NC	4	100.0	75.0
WI	4	100.0	75.0
CO	6	100.0	50.0
HI	4	100.0	50.0
KS	6	100.0	50.0
MA	4	100.0	50.0
MT	6	100.0	50.0
TX	5	100.0	40.0
GA	3	100.0	33.3
OR	6	100.0	33.3
ND	9	88.9	22.2
ID	6	83.3	66.7
KY	6	83.3	66.7
NH	6	83.3	66.7
NJ	6	83.3	50.0
NM	6	83.3	50.0
WA	6	83.3	50.0
ME	5	80.0	60.0
MN	5	80.0	60.0
MO	5	80.0	60.0
NV	5	80.0	60.0
RI	5	80.0	60.0
UT	5	80.0	60.0
AZ	4	75.0	75.0
MI	4	75.0	50.0
IN	7	71.4	28.6
OK	6	66.7	66.7
WY	8	62.5	62.5
SC	5	60.0	60.0
OH	5	60.0	20.0
NE	5	60.0	0.0
VT	7	57.1	57.1
DE	7	57.1	0.0
IA	6	50.0	50.0
MS	4	50.0	50.0
MD	6	50.0	16.7
WV	7	42.9	42.9
SD	7	42.9	28.6
AK	7	14.3	14.3
US	6	66.7	50.0

Note: The needed RDFs are calculated from the HP filter. The information on each state's RDF balance and general fund balance before each fiscally stressed period is obtained from the NASBO's Fiscal Survey of States. The period for Connecticut is from FY 1993 to FY 2012.

Pollock and Suyderhoud, 1986; Sobel and Holcombe, 1996b; Navin and Navin, 1997; Gonzalez and Levinson, 2003). For instance, the article by Navin and Navin (1997)—the most cited paper in this literature—writes a linear time model as

$$y_t = \beta_0 + \beta_1 t + \varepsilon_t,$$

in which it is implicitly assumed that state revenue grows by a constant dollar amount each year. It then estimates the long-term revenue component by

$$\hat{\tau}_t = \hat{\beta}_0 + \hat{\beta}_1 t.$$

The residual term is therefore regarded as the short-term revenue component associated with business cycles. We replicate their model and run a separate regression for each of the 50 states and the United States as a whole to estimate state-specific coefficients (see Appendix Table A2).

While easy to interpret and implement, the linear time model is problematic for several reasons. First, there is no economic reason to believe that the long-term component of state revenue should be linearly related to time. Second, using the linear time model to fit the data violates a crucial statistical assumption about data stationarity. An augmented Dickey-Fuller (ADF) unit-root test shows that the residuals of the linear time model for most states are not stationary. The p-value

Table 5
Average savings deficiency for fiscally stressed periods with insufficient state savings. (FY 1988 — FY 2012, as a percentage of state general expenditure).
Source: Author's calculations.

State	Needed RDF - RDF balance	Needed RDF - (RDF balance + general fund balance)
AK	11.5	4.0
AZ	7.8	7.6
CA	7.6	6.8
NV	7.0	6.4
HI	6.4	2.4
MS	5.9	5.7
WY	5.7	4.9
CT	5.5	4.9
NJ	5.3	6.3
IL	5.3	4.9
NC	5.0	5.6
GA	4.8	7.3
KS	4.6	6.1
WV	4.3	2.6
CO	4.3	3.8
OR	4.3	3.8
MO	4.3	4.0
UT	4.2	4.7
MI	4.1	6.5
ME	4.0	4.0
NM	3.9	3.4
WI	3.9	2.6
PA	3.9	3.6
TX	3.8	6.1
ID	3.8	2.4
FL	3.8	3.2
TN	3.6	3.5
RI	3.5	3.6
SC	3.5	1.9
LA	3.2	4.9
OK	3.2	2.6
AR	3.2	3.0
NY	3.1	3.4
IN	2.9	1.3
MT	2.8	1.6
MD	2.8	7.3
DE	2.6	0.0
VA	2.5	2.6
MA	2.5	4.1
OH	2.4	2.3
ND	2.2	4.3
VT	2.2	2.9
IA	2.2	1.8
AL	2.1	1.5
MN	2.0	1.1
SD	1.9	2.1
KY	1.9	1.7
NH	1.9	1.7
WA	1.8	1.1
NE	1.5	0.0
US	2.8	2.0

Note: We define a savings deficiency as the needed RDF for a fiscally stressed period minus state savings (the RDF balance or the sum of the RDF balance and the general fund balance) immediately before that period, if the difference of the two is positive (both expressed as a percentage of state general expenditure in the year immediately before that fiscally stressed period). The needed RDFs are calculated from the HP filter. The information on each state's RDF balance and general fund balance before each fiscally stressed period is obtained from the NASBO's Fiscal Survey of States. The period for Connecticut is from FY 1993 to FY 2012.

of the ADF test is above 0.1 for 42 states (Appendix Table A2). Third, because the linear time model does not fit the data well (that is, it produces a relatively low R-squared), it often generates large residual terms. This leads to overestimating the absolute size of the short-term component of state revenue and thereby the needed RDF size. In addition, the estimated coefficients of the linear time model depend critically upon the sample period studied. For example, we find that the decision of whether or not to include the Great Recession period has a significant impact on the estimated long-term revenue component in prior years.

To relax the restrictive linear assumption, this paper experiments with a quartic polynomial model of time. Clemens and Miran (2012) and Clemens (2013) use this more flexible model to detrend personal income and state spending. This model is written as

$$y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \beta_4 t^4 + \varepsilon_t.$$

It yields the following estimated long-term revenue component:

$$\hat{\tau}_t = \hat{\beta}_0 + \hat{\beta}_1 t + \hat{\beta}_2 t^2 + \hat{\beta}_3 t^3 + \hat{\beta}_4 t^4.$$

Appendix Table A3 shows the estimated coefficients from the quartic time model for each state.

Just as no economic theory underlies the linear time model, there is also no economic theory to support the quartic time model. While more flexible than the linear model, the quartic polynomial model is still limited in its range of curve shapes. As a result, it may not fully describe the long-term component of state revenue. It also mechanically creates waves in the estimated long-term revenue component, which may not make economic sense (StataCorp, 2013). In addition, the residual terms of this model are still not stationary for six states whose p-value in the ADF test is above 0.1 (see Appendix Table A3).[16]

4.2.2. Filtering

Both the linear and quartic time models are regression-based, parametric approaches that depend critically upon an assumption about the long-term time trajectory of state revenue. The assumption likely does not hold in reality. Therefore, we propose using a nonparametric and more flexible approach—filtering—that does not require such a strong assumption.

The Hodrick-Prescott (HP) filter is the most commonly used filter in the economics field.[17] It assumes $y_t = \tau_t + c_t$, where c_t has a mean of zero. The filter extracts the long-term component τ_t from the data by solving the following optimization problem:

$$\min_{\tau_t}\left[\sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1}\{(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})\}^2\right],$$

where λ is the smoothing parameter. Minimizing the first term penalizes the cyclical component, which represents a deviation from the long-term component. Minimizing the second term penalizes changes in the growth rate of the long-term component (which is analogous to minimization of the second derivative of the long-term component) in order to maximize the “smoothness” of the long-term component series. The larger the value of λ, the higher the penalty in the second term and therefore the smoother the long-term component series. The common practice is to set λ at 6.25 for annual data (Ravn and Uhlig, 2002).[18]

Unlike the linear and quartic time models, the filtering approach is able to obtain a short-term component that is always stationary. King and Rebelo (1993) show that the HP filter is “capable of rendering stationary any integrated process up to fourth order” (p. 220). Our tests

[16] We also tried a fractional polynomial model of time, for which the functional form was determined by a systematic search for a combination of powers to best fit the data. The estimation results are similar to those from the quartic time model. However, 18 states have nonstationary residuals in the fractional polynomial model, compared with six states that have nonstationary residuals in the quartic polynomial model. For this reason and also for the sake of saving space, we do not report the results from the fractional polynomial model in the paper.

[17] As part of the robustness check, we also tried the CF filter. It produces similar results as the HP filter. In the interest of saving space, we do not report the results from the CF filter in the paper.

[18] We also tried $\lambda = 10$, used by Wagner and Elder (2005) to separate the cyclical component from annual state expenditure. Using $\lambda = 10$ produced very similar results as in the case of $\lambda = 6.25$.

confirm that the data on adjusted state own-source general revenue of each state and the U. S. as a whole are either I(1) or I(2). Therefore, the HP filter is suitable to use on these data. In addition, the HP filter is more robust to outliers than the linear and quartic time models.[19]

The filtering approach has its own drawbacks. First, it is less transparent and more difficult to understand than the income-based method and the linear and quartic time models. Second, if the economy goes through an unusually prolonged expansion or contraction, the filter could misclassify part of the true short-term component into the long-term component. That would lead to underestimating the short-term component. In addition, the filtering approach has a tendency to pull the estimated long-term component closer to the actual data point in the beginning and final years of the sample period, which introduces another downward bias in estimating the short-term component.[20] Therefore, using the HP filter is likely to underestimate the absolute size of the negative short-term revenue component associated with the Great Recession.

By construction, the short-term revenue components estimated by the HP filter and the linear and quartic time models have a mean of zero. Therefore, the total of the positive short-term revenue components (that is, revenue swings above trend) and the total of the negative short-term revenue components (that is, revenue dips below trend) cancel out each other in the entire sample period.

5. Determining the needed RDF size

We compare the estimated short-term revenue component from the four above methods. The purpose of the comparison is to examine how similar or dissimilar the results of these estimation methods are and whether there is one method that generally outperforms the others across states. The criteria for a better-performing method are that it: (1) consistently identifies a negative short-term revenue component around each recession period; and (2) shows the relative size of the short-term revenue component across the recessions to be consistent with what we observe in terms of states' actual experience. For example, we expect a larger negative short-term revenue component for most states around the 2000s' recessions than around the 1990–1991 recession because states reported unprecedentedly large revenue shortfalls during the 2000s' recessions than during previous recessions, even though the 2001 recession itself was relatively short and shallow (McGranahan and Mattoon, 2012b; Gordon, 2012). The preferred method based on these criteria will later be used to determine the needed RDF size for each state.

We first perform the comparison for the United States as a whole, as shown in Fig. 1, which serves as a general case, and then for each of the 50 states, as shown in Appendix Fig. A2. To make the estimated short-term revenue component relatively comparable across states in these figures, we divide it by the average of the nation's or each state's general expenditure over FY 1988–FY 2012.[21] In addition to the national recession shading, we add a series of unemployment deviation, which is defined as the difference between annual unemployment rate and the average unemployment rate for the nation or each state between 1988 and 2007 (excluding the unusually high unemployment rates during the Great Recession period to avoid the outlier impact on the average). This unemployment deviation series serves as an alternative, although imperfect, indicator of the economic condition, considering that there is no official dating for each state's business cycles.[22]

There are some similarities in the short-term revenue component estimated by different methods in Fig. 1. First, the curve shapes are similar across the estimation methods. In particular, the estimated short-term component from the HP filter, the quartic time model, and the income-based method closely track one another. Second, the four methods all show a negative short-term revenue component around each of the three past national recessions. The estimated short-term revenue component also largely moves in opposite direction from the unemployment deviation.[23] The negative short-term revenue component often occurs when the unemployment deviation is positive. Combining these points suggests that there are indeed negative short-term revenue components associated with each recession.

There are also some dissimilarities among the estimation methods. First, the estimated short-term component from the linear time model shows significantly larger swings than the ones estimated from other methods. This reflects the poor fit of the estimates and the non-stationarity of the residual term in the linear time model. Second, the linear time model shows a much smaller estimated negative short-term component around the 2001 recession than around the 1990–1991 recession, which contradicts most states' actual experience. This result comes from the linear time model's high sensitivity to outliers, which causes the regression line to be pulled flatter and lower by the historical revenue declines during the 2000s' recessions, resulting in a smaller residual term (that is, the estimated short-term component) around the 2001 recession. Third, among other methods that produce similar results, the income-based method generally provides the largest estimate, while the HP filter generally provides the smallest estimate of the negative short-term revenue component around each recession.

These similarities and dissimilarities across the estimation methods also exist for individual states (Appendix Fig. A2).[24] It is worth noting that unlike the HP filter, the other methods are unable to consistently identify the negative short-term revenue component associated with each recession across states. The linear time model fails to reveal a negative short-term revenue component around the 2001 recession for 14 states.[25] The income-based method shows no negative short-term revenue component for either Kentucky or Louisiana around the 2001 recession, nor does it show one for either Michigan or New Hampshire around the 2007–2009 Great Recession. This reflects the fact that the income-based model may not capture all the underlying operating determinants, which could be particularly true for some states heavily dependent on tax exporting (for example, New Hampshire) and for

[19] As part of robustness check, we tried dropping the 2008–2012 Great Recession and subsequent period when states experienced large revenue shortfalls. This barely affects the results in 1988–2007 under the HP filter, while significantly affecting the results from the linear time model. The quartic time model is in the middle in terms of the impact on the results in the prior period of dropping later years' data.

[20] Mise et al. (2005) show that for any I(1) or I(2) data process, the HP filter is still "optimal," in the sense of achieving the minimal mean squared errors, at the data series center.

[21] To further facilitate an across-state comparison, in Appendix Fig. A2. we put the calculated ratio on the same scale of minus 20 percent to plus 20 percent for the nation and for each state except Alaska and North Dakota. These two energy-producing states have a wider range in the estimated short-term revenue component than other states and therefore require a larger scale in their figures.

[22] The unemployment rate is only one of many economic indicators that the NBER considers when dating U.S. business cycles. "It examines and compares the behavior of various measures of broad activity: real GDP measured on the product and income sides, economy-wide employment, and real income. The Committee also may consider indicators that do not cover the entire economy, such as real sales and the Federal Reserve's index of industrial production (IP)." (See http://www.nber.org/cycles/recessions.html) The NBER notices that while the unemployment rate often moves in the opposite direction from most other above mentioned indictors, the timing is not in perfect sync. That is, "the unemployment rate is often a leading indicator of the business-cycle peak" and "a lagging indicator" of the business-cycle trough (See http://www.nber.org/cycles/recessions_faq.html).

[23] The correlation between the unemployment deviation and the short-term revenue component estimated by the HP filter is −0.51 and statistically significant at the 1 percent level.

[24] The correlation between the unemployment deviation and the short-term revenue component estimated by the HP filter is always negative and mostly significant at the 10 percent or lower level for all states, except for Wyoming which correlation is positive, but almost zero and statistically insignificant.

[25] These states are California, Florida, Georgia, Kentucky, Louisiana, Maine, Michigan, Missouri, Nebraska, Ohio, Rhode Island, Virginia, Washington, and Wisconsin. All these states did experience a state-level recession around the 2001 national recession, according to Owyang et al. (2005).

some energy-producing states (for example, Kentucky and Louisiana).[26] The quartic time model is almost as consistent as the HP filter in identifying the negative short-term revenue component around each recession except for Maine around the 1990–1991 recession and Michigan around the 2007–2009 Great Recession.

As a result of this comparison, we choose the HP filter as our preferred method. It is more consistent than the other methods in identifying the negative short-term revenue component around each recession. It usually provides a smaller estimate of the absolute size of the short-term revenue component than other methods, so we use it later to develop a measure of the needed RDF size that is less likely to be overestimated.

The quartic time model or the income-based method provides the second smallest estimate. These can be used by states to gauge the sensitivity of the findings to model specification.[27] Nonetheless, the income-based method should not be used for states that heavily rely on an energy severance tax or a capital gains tax or tax exporting, or states that have experienced extraordinary changes in personal income. We recommend against the use of the linear time model in all cases, even though it has been extensively used in the literature.

To calculate the needed RDF for each fiscally stressed period, we take the sum of the negative short-term revenue components over the period during which a negative short-term revenue component occurs. This sum represents the amount of savings that a state would need before entering the fiscally stressed period in order to offset revenue dips below trend and maintain state spending in line with the long-term revenue component for that period, without raising tax rates or collecting more in fees and charges.[28] Following Navin and Navin (1997), we next divide each needed RDF by state general expenditure in the year immediately preceding the fiscally stressed period in order to facilitate comparisons of needed RDF across states and comparisons of needed RDF with the RDF cap or balance within individual states.[29]

For example, Massachusetts experienced an estimated negative short-term revenue component of \$0.3 billion and \$2.1 billion for FY 2009 and FY 2010, respectively, according to the HP filter. Therefore, the needed RDF for the fiscally stressed period of FY 2009–FY 2010 is \$2.4 billion, or about 5.4 percent of Massachusetts's FY 2008 state general expenditure of \$43 billion. This means that if Massachusetts had accumulated 5.4 percent of state general expenditure in its RDF in FY 2008, it would have had enough money to cover the negative short-term revenue component in the next two fiscal years.

Most states and the United States as a whole have experienced more than three fiscally stressed periods in the last 25 years. The number of fiscally stressed periods is larger than the number of national recessions for at least two reasons. First, the savings and loan crisis and the related collapse of the commercial real estate market and some regional housing markets occurred from 1986 to 1995, which covers a much longer period than the NBER-declared July 1990–March 1991 recession. Therefore, many states experienced a poor economy and underperforming revenue in the late 1980s and in the mid-1990s. This

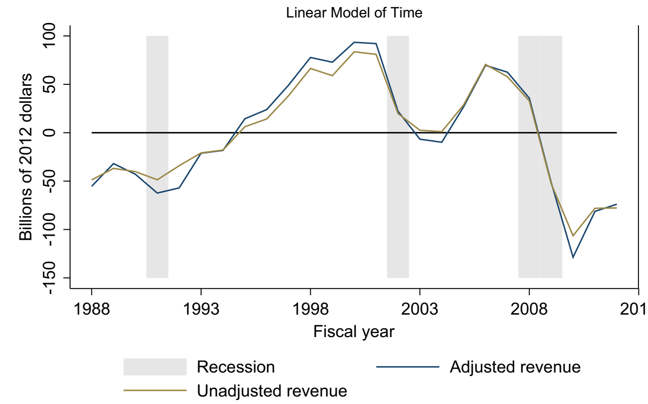


Fig. A1. Estimated short-term component of state revenue for U.S. (results from the linear model of time).

results in the addition of two or three fiscally stressed periods to the national recession-related fiscally stressed periods. Second, as Owyang et al. (2005) show, many states have experienced additional, state-specific recessions that were unrelated to a national recession. This also results in more fiscally stressed periods for individual states.

For example, Massachusetts experienced four fiscally stressed periods from FY 1988 to FY 2012, including FY 1990–FY 1991, FY 1994–FY 1997, FY 2002–FY 2004, and FY 2009–FY 2010. Its needed RDF as a percentage of state general expenditure across these fiscally stressed periods ranges from 3.4 percent to 10.2 percent, with the median needed RDF of 5.5 percent.

Following the recommendation of Gold (1995), we introduce a second factor in choosing the needed RDF size: the desire for stable state tax rates and spending, which may vary across states. Depending upon how strongly policymakers prefer stable tax rates and spending, they can choose a different percentile of the distribution of the needed RDFs as their target level. For example, if a state has a strong preference for not raising tax rates even in the worst fiscally stressed period, then it should aim for the maximum of the needed RDFs. If, on the other hand, a state is willing to implement some tax rate increases during periods of unusually severe fiscal distress, it may want to set a lower target for its RDF. For instance, a state that wishes to have sufficient savings to deal with only half of the fiscally stressed periods could choose the median of the needed RDFs across fiscally stressed periods as its target level.[30]

Table 1 shows the maximum of the needed RDFs during the FY 1988–FY 2012 period using our preferred HP filter method as well as the other methods for comparison. Consistent with the patterns in Fig. 1 and Appendix Fig. A2, the result from the HP filter is almost always the smallest for each state.[31] To further test the credibility of the result from the HP filter, we run a correlation across the 50 states

[26] We run a linear regression of state revenue on personal income for Michigan (Appendix Table A1). Because the linear model is sensitive to outliers and Michigan experienced an unusually large decline in personal income during the Great Recession, its regression line is flatter and lower than it would otherwise be. As a result, the estimated long-term revenue component is even smaller than the actual revenue amount, which causes the estimated short-term revenue component to be positive around the time of the Great Recession for Michigan.

[27] A possible option for some states is to use an average of the results from the HP filter and the results from the quartic time model as the measure of their short-term revenue component.

[28] Because our data period is restricted to FY 1988–FY 2012, we do not know the short-term component of state revenue outside this period. Therefore, we are likely to underestimate the needed RDF for some states' fiscally stressed periods that include FY 1988 or FY 2012, because the short-term revenue component in FY 1987 (and maybe even earlier years) or in FY 2013 (and maybe even later years) might also be negative for those states.

[29] States generally define their RDF caps and refer to their RDF balances as a percentage of annual state revenue or expenditure.

[30] We implicitly assume that the frequency, duration, and magnitude of future economic and revenue cycles are likely to resemble those in the FY 1988–FY 2012 period. However, if a state believes that the needed RDFs in this historical period are on the upper end of its universal distribution of the needed RDFs, it may consider lowering its target level by choosing a lower percentile of the distribution of the needed RDFs in FY 1988–FY 2012. In the opposite case, they may choose a higher percentile of the distribution of the needed RDFs. If states anticipate a more severe fiscally stressed period than they ever experienced in FY 1988–FY 2012, they may choose an even higher RDF level than the maximum needed RDF we estimated.

[31] The only exception is Rhode Island, where the maximum from the quartic time model is somewhat smaller than the maximum from the HP filter. For most states, the result from the quartic time model is similar to the result from the HP filter. The difference between the two calculations is within 5 percentage points for 33 states. In addition, either the linear time model or the income-based method provides the largest number for each state, which is often too large to be credible from a common sense or political feasibility standard. For example, 12 states have a number from the linear time model that is above 50 percent of state general expenditure. Three of these states have a number above 100 percent, implying an extremely high required rate of saving when revenues exceed their long-term trend.

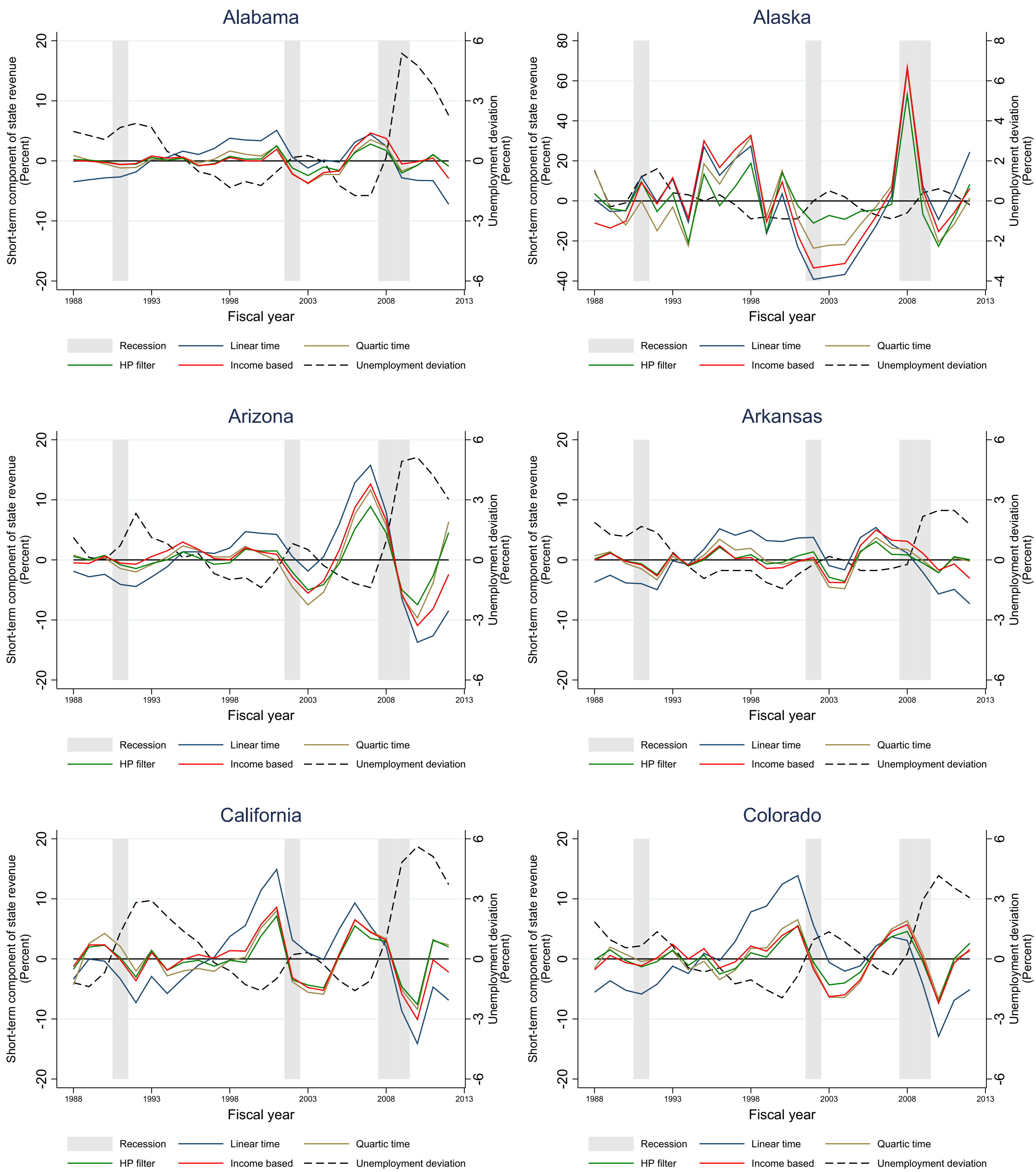


Fig. A2. Estimated short-term component of state revenue for 50 states and the U.S.

between the maximum needed RDF from the HP filter and the 2000–2012 short-term elasticity of total state tax revenue relative to personal income estimated by Kodrzycki (2014). This short-term income elasticity of total state tax revenue is an alternative measure of revenue cyclicality. In general, a state with a higher short-term income elasticity of state tax revenue is expected to have a larger maximum needed RDF. We find that the correlation between the two is 0.5 and highly statistically significant with a p-value of less than 0.001.[32]

[32] The correlation should be less than 1, because: (1) our adjusted state own-source general revenue includes both tax revenue and nontax revenue, while Kodrzycki (2014) examines only unadjusted state tax revenue; (2) the two estimates are not drawn from

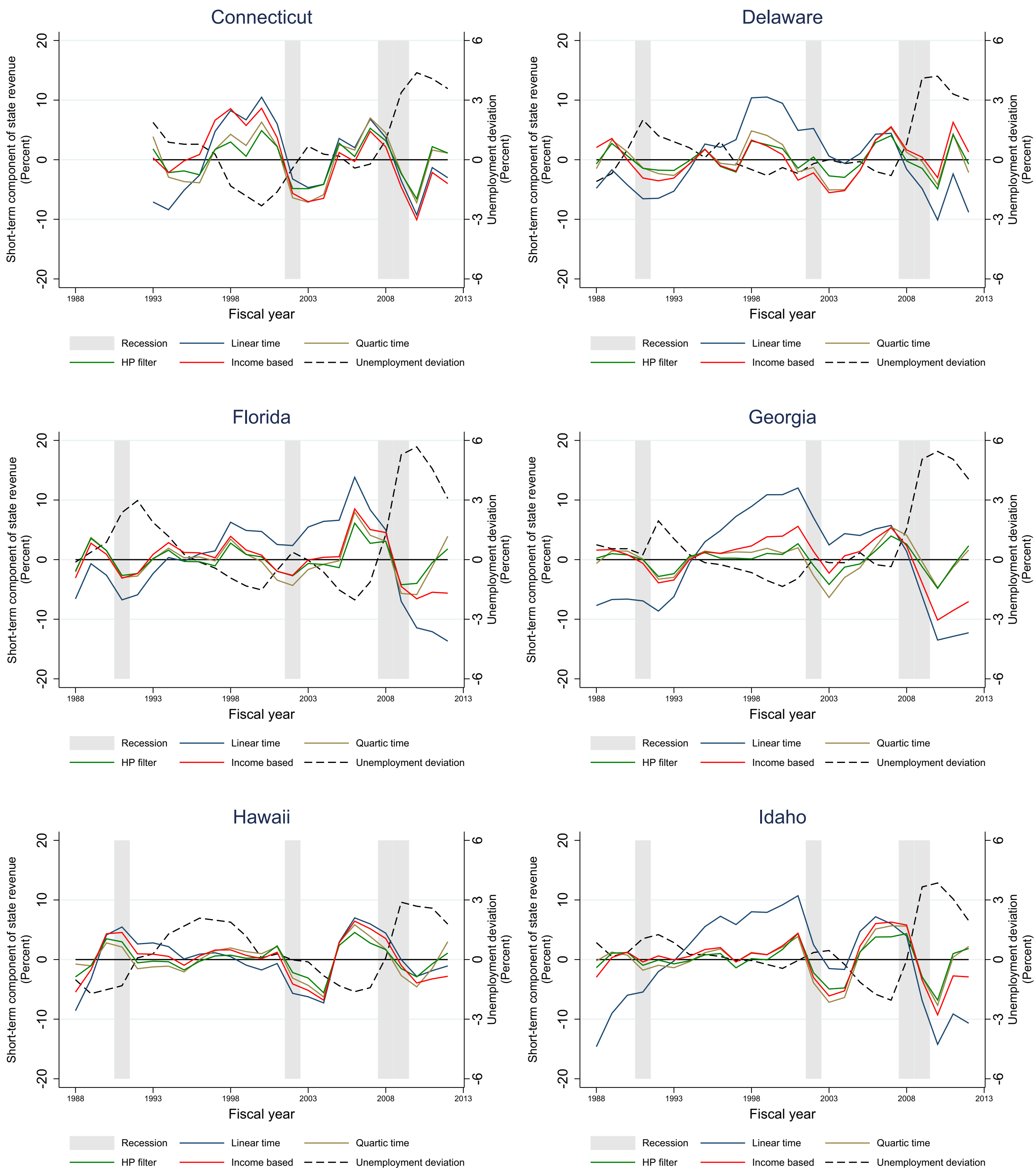


Fig. A2. (*continued*)

States have different maximum needed RDFs estimated from the HP filter method. As expected, some energy-producing states (for example, Alaska, New Mexico, North Dakota, and Wyoming), some states that rely heavily on a capital gains tax (for example, California, Connecticut, Massachusetts, New Jersey, and New York), and some states that depend critically upon volatile gambling revenue (for example, Nevada and New Jersey) have a larger maximum needed RDF than the one for the United States as a whole or for the 50-state average. Appendix Fig. A3 shows the spatial distribution of states' maximum needed RDFs. States with relatively high maximum needed RDFs tend to cluster in the Northeast and West regions.

(*footnote continued*)
identical periods.

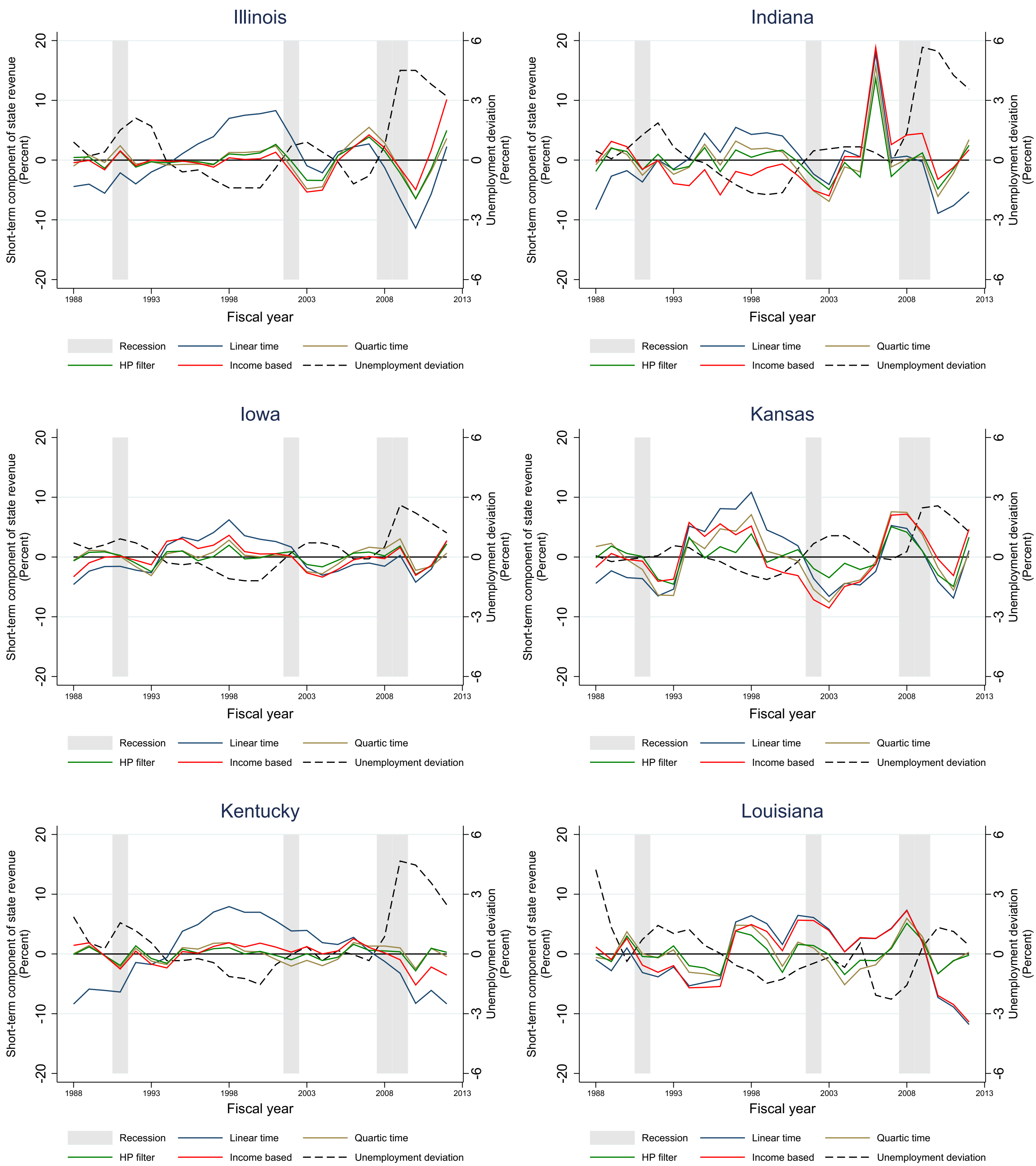


Fig. A2. (*continued*)

Table 2 shows the median of the needed RDFs during the FY 1988–FY 2012 period, which provides a lower potential target level.[33] The patterns across methodologies are similar to those shown in Table 1. The number from the HP filter is the smallest for 27 states. In cases where it is not the smallest, it is often very close to the smallest, usually within one percentage point.

[33] As Appendix Fig. A2 indicates, the revenue shortfall from trend and therefore the needed RDF for some states in a few fiscally stressed periods are very small. Including these periods has no impact on our estimate of the maximum needed RDF but lowers our estimate of the median needed RDF. One option for these states is to choose a higher percentile than the median of the needed RDFs. Alternatively, one may choose the median of the needed RDFs for only the fiscally stressed periods whose revenue shortfalls from trend must pass a certain threshold; however, setting such a threshold would be arbitrary.

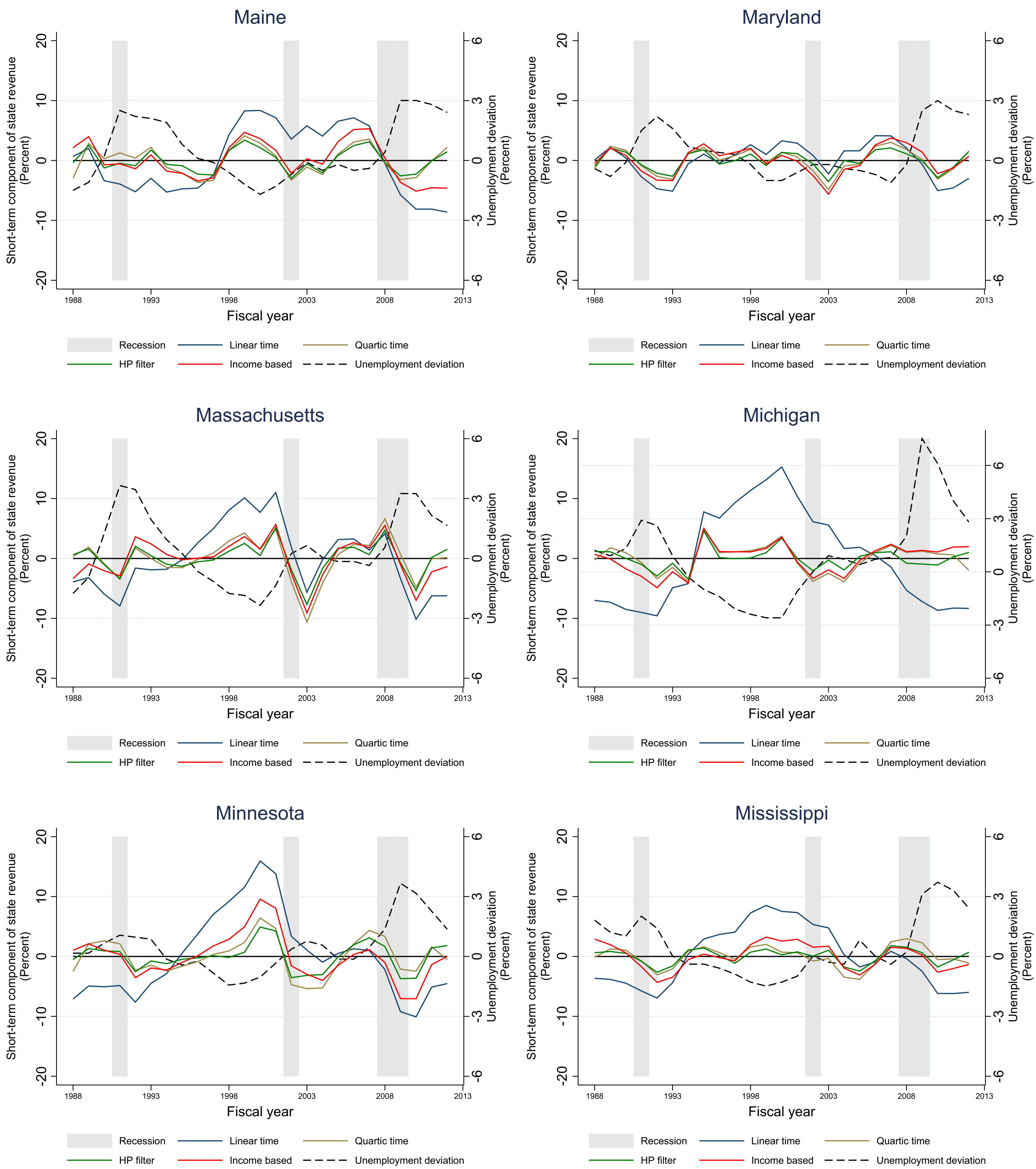


Fig. A2. (*continued*)

The size of the median needed RDF varies across states. Most of the aforementioned states such as Alaska, California, Connecticut, Massachusetts, Nevada, New Jersey, and Wyoming again have a larger median needed RDF from the HP filter than that for the United States as a whole or the 50-state average.[34] In general, states with a larger maximum needed RDF are very likely to have a larger median needed RDF. The correlation between the two (both from the HP filter) is 0.8 with a p-value less than 0.0001. In addition, the median needed RDF from the HP filter is positively and statistically significantly correlated with the 2000–2012 short-term income elasticity of total state tax revenue in Kodrzycki

[34] Appendix Fig. A4 shows the spatial distribution of states' median needed RDFs.

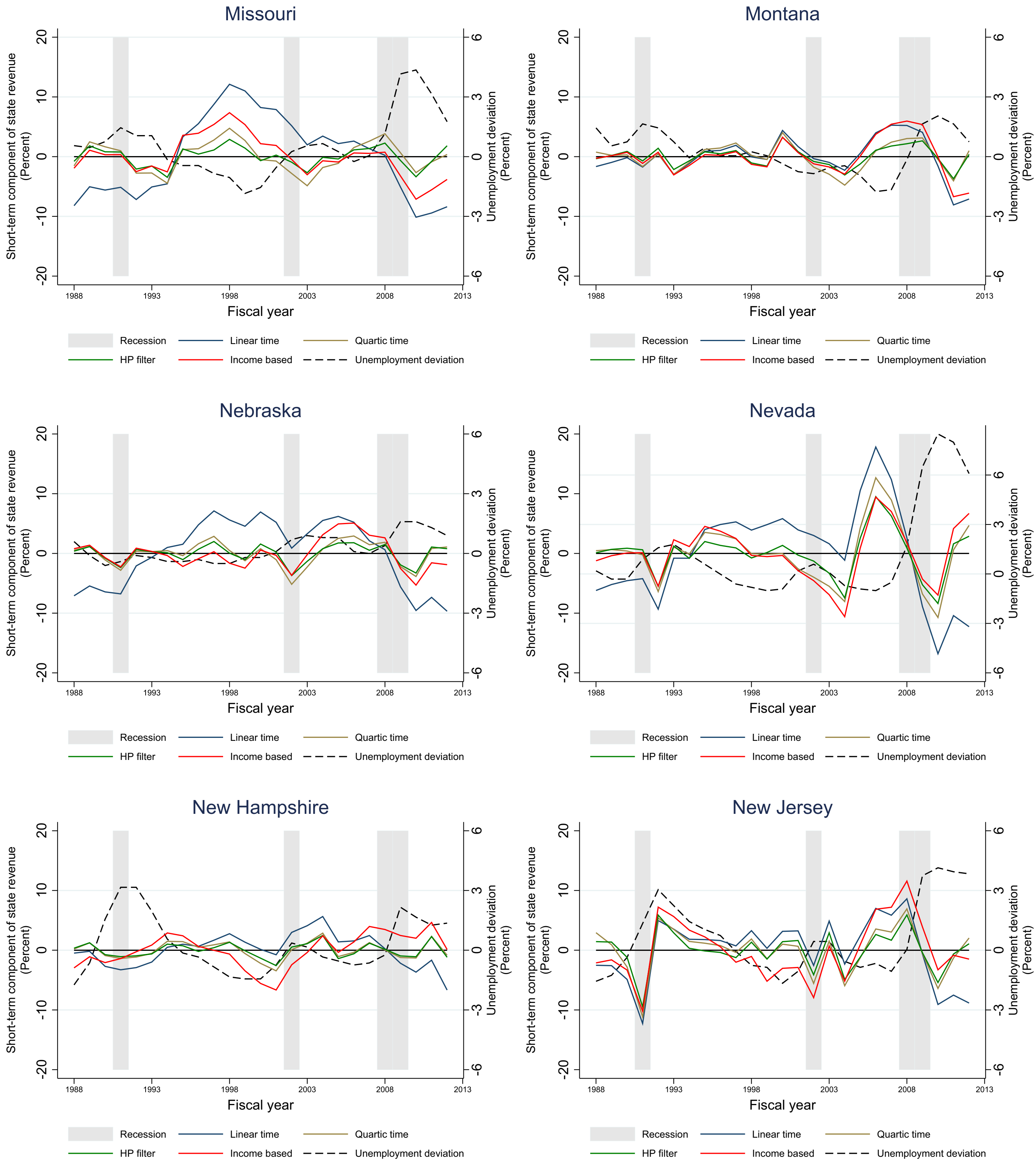


Fig. A2. (*continued*)

(2014), with a correlation of 0.4 that is significant at the 1 percent level.[35]

6. Evaluating state RDF caps and balances

Forty states have imposed an upper limit or so-called cap on the size of their RDFs (McNichol and Boadi, 2011).[36] These caps can

[35] We also run a correlation between Kodrzycki's elasticity measure and the maximum or median needed RDF from the three other methods. The quartic time model is the only other method that yields both the maximum and the median positively and statistically significantly correlated with Kodrzycki's elasticity measure. This is not very surprising, given that the results from the HP filter are more similar to the results from the quartic time model than to the results from the other methods.

[36] Vermont has multiple reserve funds, including: (1) the General Fund Budget Stabilization Reserve, (2) the General Fund Balance Reserve (also known as "the Rainy Day Reserve"), (3) the Transportation Fund Budget Stabilization Reserve, (4) the

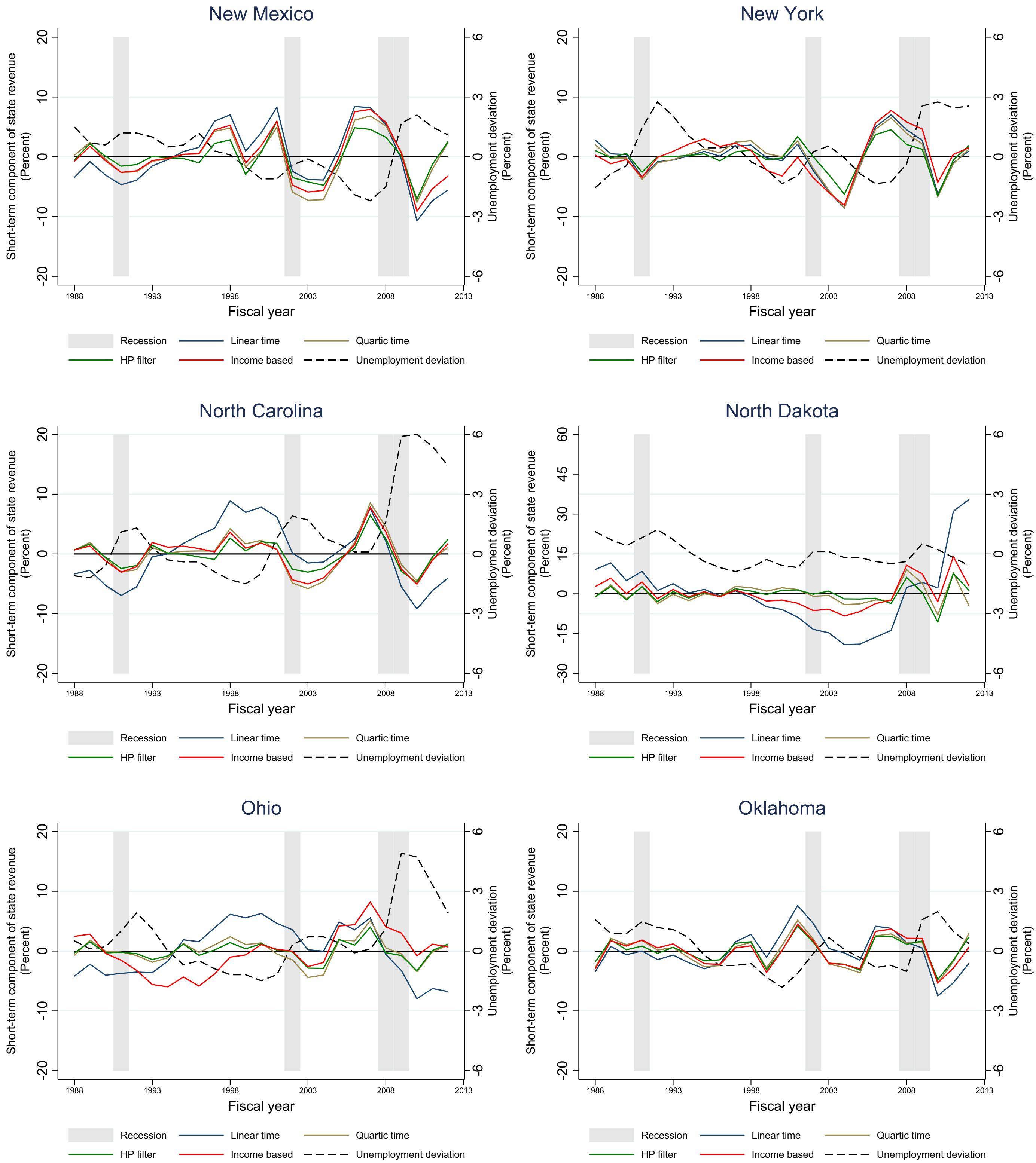


Fig. A2. (*continued*)

(*footnote continued*)
Transportation Fund Balance Reserve, (5) the Education Fund Budget Stabilization Reserve, and (6) the Human Services Caseload Reserve (recently repealed). Each reserve fund has its own cap. However, reserve funds (2)–(6) do not have all three required distinct features of RDFs—"enabling legislation, going across budget cycles, and serving the whole government entity" (Hou, 2005, p. 120). Therefore, they are technically not counted as RDFs for this study. In addition, Vermont reported only the balance of the General Fund Budget Stabilization Reserve when answering a question on the RDF balance in the NASBO's annual Fiscal Survey of States.

negatively impact the effectiveness of the RDFs if they are set too low. To evaluate state RDF caps, we compare them with the median and maximum needed RDF calculated from the HP filter (Table 3). States usually define their RDF caps as a percentage of general fund revenue or expenditure. General fund revenue or expenditure is often much smaller than the Census Bureau-defined general expenditure. The scope of the general fund is also less consistent across states and over time than general expenditure. Therefore, to make the caps and the

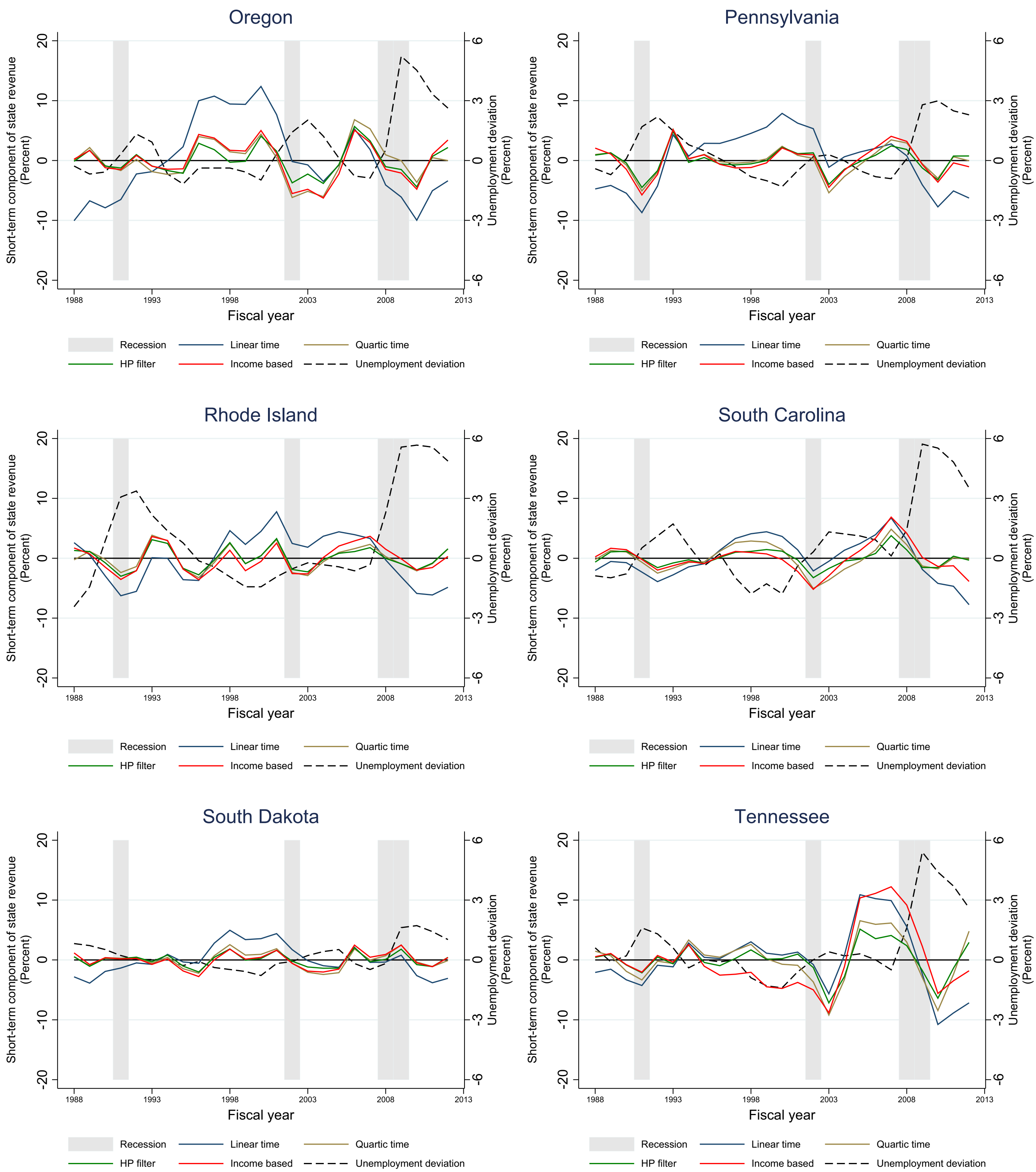


Fig. A2. (*continued*)

needed RDFs relatively comparable, we multiply the RDF caps by each state's average ratio of general fund expenditure to general expenditure over the 1988–2012 period. In doing so, we express both the RDF caps and the needed RDFs in relation to state general expenditure.

If a cap is lower than the median needed RDF, it means that even if a state manages to maintain its RDF at the cap level before each fiscally stressed period, it will not have enough reserves to deal with at least half of those difficult periods. If a cap is below the maximum needed RDF, it is clearly impossible for the state to have enough in its RDF to handle the most severe fiscally stressed period.

We find that many states set their RDF cap below the needed RDF. In 23 states the cap is lower than the median needed RDF. Arizona has the largest gap of 4.8 percentage points between the cap and the median needed RDF. These 23 states plus 13 other states have a cap

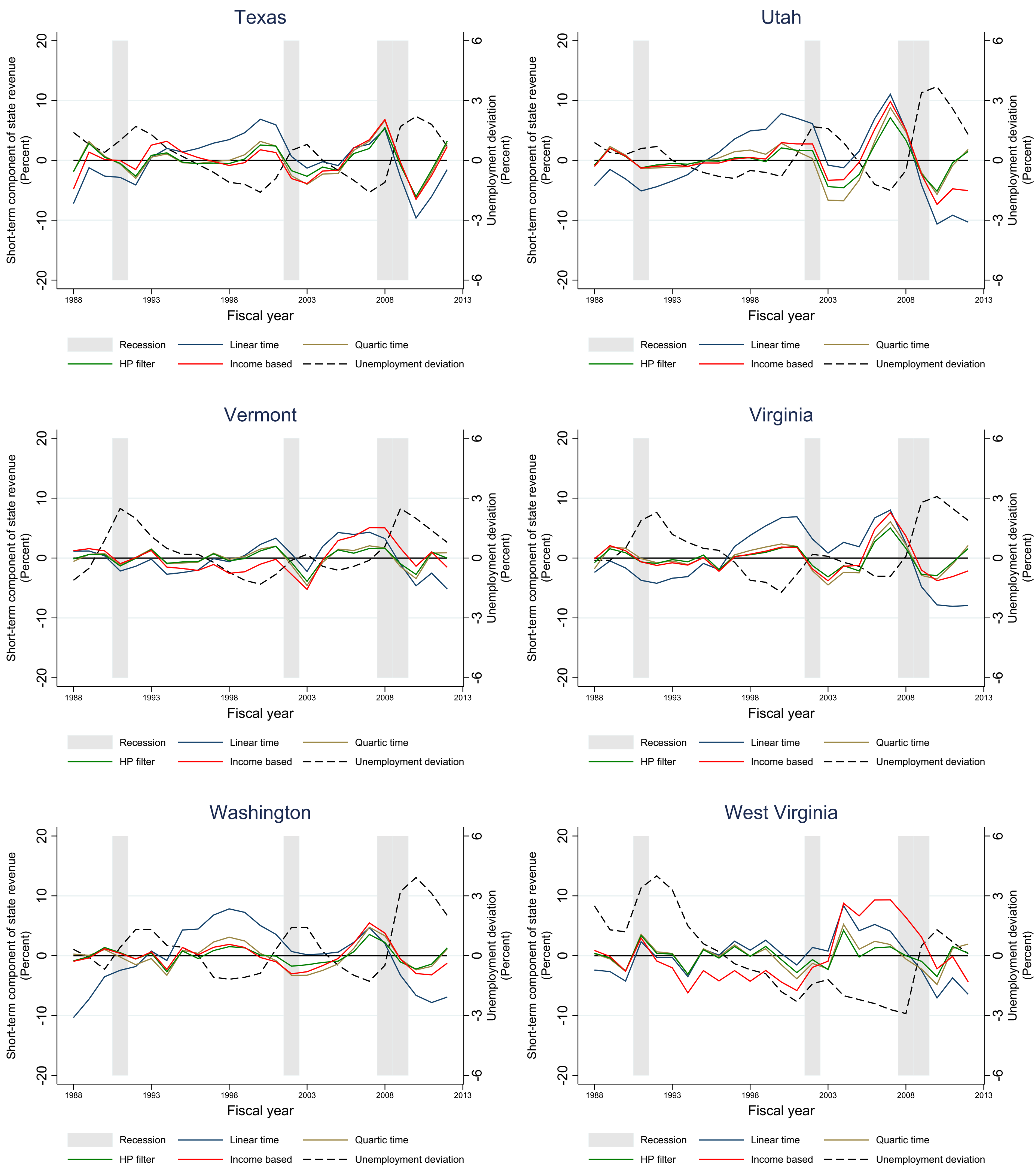
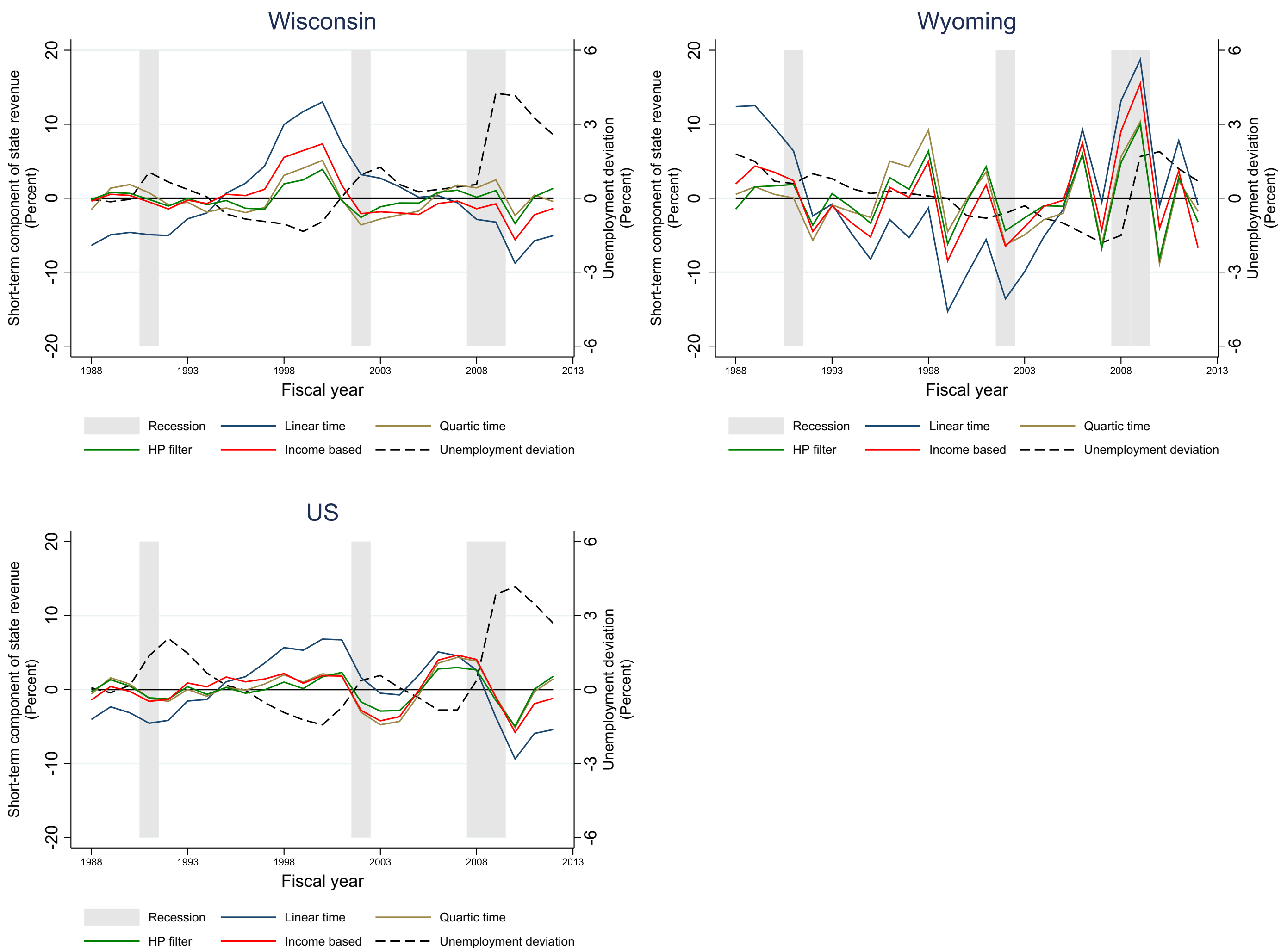


Fig. A2. (*continued*)

below the maximum needed RDF. In other words, only four of the 40 states with a cap could have saved enough in their RDFs to deal with the most severe fiscally stressed period, if they had managed to accumulate funds equal to the cap level before this fiscally stressed period. These four states are Georgia, Massachusetts, Oklahoma, and Virginia, all of which set the cap at 15 percent of general fund revenue or expenditure. On the other end of the spectrum, New Jersey's cap is 10.8 percentage points lower than the maximum needed RDF—the largest gap among all states.

In response to concerns over the low RDF caps, some states have recently been considering proposals on reforming their RDF caps. For example, Connecticut Governor Malloy proposed in early 2014 to



Note: The estimated short-term component of state revenue is presented as a percentage of each state's average general expenditure from FY 1988 to FY 2012. Unemployment deviation represents the difference between annual unemployment rate and the average unemployment rate for each state between 1988 and 2007.

Fig. A2. (*continued*)

increase the RDF cap from 10 percent to 15 percent of state general fund revenue, which would be very close to the maximum needed RDF calculated for Connecticut (State of Connecticut 2014).

In reality, most states have been saving much less than their caps allow, which further reduces the effectiveness of the RDF. To measure the frequency of undersaving, we compute the percentage of fiscally stressed periods between FY 1988 and FY 2012 when the needed RDF exceeded the RDF balance immediately before those fiscally stressed periods. Because general fund balance may be a substitute for the RDF (Wagner, 2003), we also calculate the percentage of fiscally stressed periods in which the needed RDF was higher than the sum of the RDF balance and the general fund balance before those fiscally stressed periods.[37] We obtain the information on both the year-end RDF balance and the year-end general fund balance from the NASBO's Fiscal Survey of States.[38]

Table 4 shows that states very often did not save enough for the fiscally stressed periods in the last 25 years. Twenty-one states have never saved enough in their RDF before entering each fiscally stressed period between FY 1988 and FY 2012. Forty-seven states and the United States as a whole did not have enough RDF funds for at least half of the fiscally stressed periods. Even after taking into account the general fund balance, the more broadly defined fund balance before each fiscally stressed period was still lower than the needed RDF for at least half of the fiscally stressed periods for 38 states and the nation as a whole.[39]

[37] However, Hou (2005) shows that general fund surplus is much less effective and reliable than the RDF in stabilizing state own-source expenditure in downturn years.

[38] Colorado (1989–2012), Illinois (2001–2009), and Kansas (1993–1995) reported a positive RDF balance in some years of the NASBO's Fiscal Survey of States. However, their reserve funds do not meet the technical criteria of RDFs and therefore are not counted as RDFs for this study (Mattoon, 2003; Hou, 2005; McNichol and Boadi, 2011). We add the reported "RDF" balance of these states to their general fund balance for the calculations in Tables 4 and 5.

[39] We also calculate how often states would have had insufficient RDFs if they had followed a rule of thumb to accumulate RDFs between FY 1988 and FY 2012. We examine two common rules of thumb, which recommend RDFs to be 5 or 15 percent of annual general fund expenditure (see Appendix Table A4). If states had strictly followed the five-percent rule, five states would have never had enough RDFs for the fiscally stressed periods in the last 25 years; 47 states and the U.S. as a whole would have had insufficient RDF funds for at least half of the fiscally stressed periods. However, following the five-percent rule would still be better than past practices of a majority of states. Twenty-nine states and the U.S. as a whole would have seen a smaller percentage of fiscally stressed periods with insufficient RDFs under the five-percent rule than under their actual RDF balances, although five states (Alaska, Mississippi, Oklahoma, West Virginia, and Wyoming) would have seen a larger percentage under the five-percent rule than under their actual RDF balances, because they had often saved more money in their RDFs than five percent of general fund expenditure.If states had strictly followed the 15-percent rule, 19 states and the U.S. as a whole would have had enough RDFs to address every fiscally stressed period, while only 5 states would have had insufficient RDF funds for at least half of the fiscally stressed periods. The U.S. as a whole and all states but two

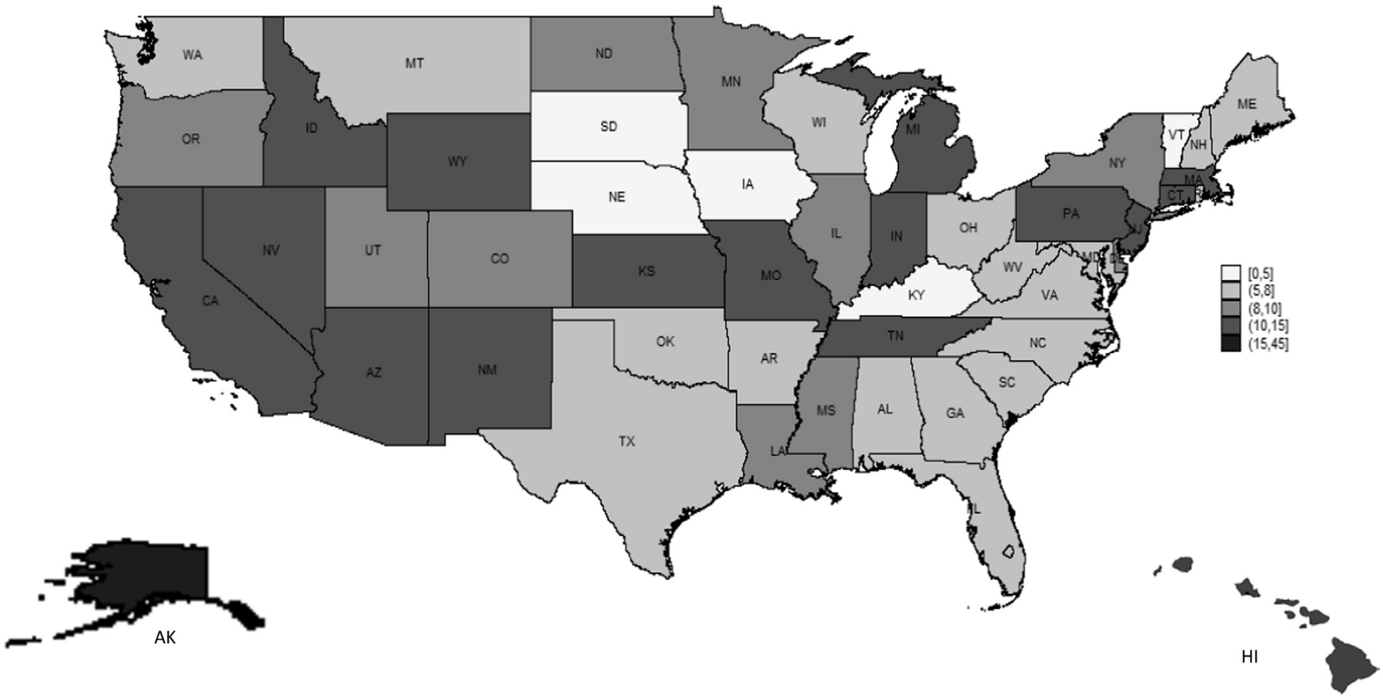


Fig. A3. Maximum needed RDF as a percentage of general expenditure. (results from the HP filter).

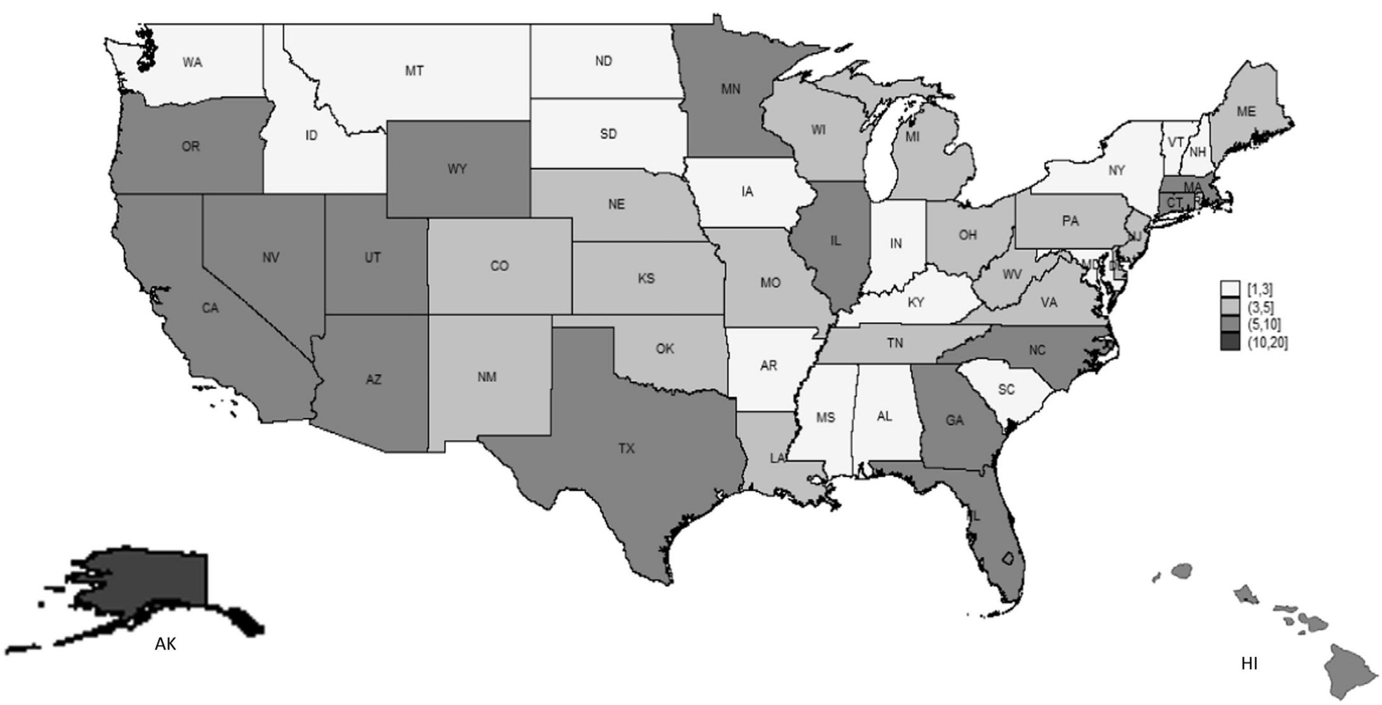


Fig. A4. Median needed RDF as a percentage of general expenditure. (results from the HP filter).

Another question asks how severe the savings deficiencies are for each state. We define a savings deficiency as the needed RDF for a fiscally stressed period minus the RDF balance just before that period if the difference between these two is positive (expressed as a percentage of state general expenditure in the year immediately before the fiscally stressed period). Then, we take an average of the savings deficiencies over the number of fiscally stressed periods when a savings deficiency occurred. We also define an alternative measure of the savings deficiency by using the sum of the RDF balance and the general fund balance before each fiscally stressed period to calculate the difference from the needed RDF for that period (Table 5).

We find that some states experienced significant savings deficiencies over the fiscally stressed periods between FY 1988 and FY 2012 when they did not save enough. Eleven states had an average of savings deficiencies above 5 percent of general expenditure, if we consider only the RDF balance. If we take general fund balance into account, still 11 states have an average of savings deficiencies equal to more than 5

(*footnote continued*)
(Alaska and Wyoming) would have experienced a smaller percentage of fiscally stressed periods with insufficient RDFs under the 15-percent rule than under their actual RDF balances.

Table A1
The estimated coefficients from the income-based model for each state.
Source: U.S. Census Bureau Annual Survey of State Government Finances, U.S. Bureau of Economic Analysis, the National Association of State Budget Officers.

State	Personal income	(Personal income)^2	Constant	Adjusted R-squared
AK	−3249	55	56005	0.02
AL	83***		304	0.93
AR	146***		−4421***	0.97
AZ	58***		2707***	0.89
CA	98***		−23908**	0.89
CO	62***		759	0.97
CT	53***		6383	0.29
DE	885***	−10***	−13381***	0.94
FL	76***		−7418***	0.95
GA	268**	−0**	−28311*	0.87
HI	90***		2183**	0.57
IA	72***		1995***	0.89
ID	356***	−3***	−5371***	0.92
IL	85***		−9434***	0.89
IN	973**	−2**	−100004**	0.68
KS	115***		−3769***	0.84
KY	976***	−3***	−58997***	0.95
LA	75***		3110	0.56
MA	790**	−1**	−112439**	0.82
MD	66***		1929*	0.94
ME	125***		−1205**	0.84
MI	126***		−14204***	0.92
MN	541**	−1**	−44732**	0.85
MO	92***		−4863***	0.86
MS	364**	−1*	−12273**	0.95
MT	99***		−214	0.87
NC	95***		−3616***	0.96
ND	−69	5**	1740	0.90
NE	790***	−5***	−24492***	0.93
NH	62***		−710**	0.87
NJ	80***		−436	0.69
NM	97***		2033***	0.77
NV	68***		287	0.97
NY	−1142*	1**	563721**	0.72
OH	1696***	−2***	−368796***	0.78
OK	295***	−1**	−12278**	0.94
OR	346**	−1*	−17030**	0.93
PA	940**	−1**	−234904**	0.91
RI	757**	−7*	−15564*	0.89
SC	90***		−52	0.93
SD	213***	−3***	−1698***	0.94
TN	67***		−162	0.71
TX	143***	−0**	−28146**	0.96
UT	109***		−616**	0.97
VA	233***	−0*	−27131**	0.97
VT	92***		144	0.85
WA	347***	−1***	−28311***	0.93
WI	93***		736	0.89
WV	263***		−8558***	0.77
WY	−403**	12***	5638***	0.83
US	87***		−71461	0.94

Note: Personal income is in billions of dollars and state revenue is in millions of dollars. Both are inflated to 2012 dollars.
* implies significance at 10 percent.
** implies significance at 5 percent.
*** implies significance at 1 percent.

percent of general expenditure.

Several potential factors may help to explain why states did not save enough in RDFs. First, states face institutional constraints that restrict the amount they can allocate towards RDFs and tighten the conditions under which they can withdraw from RDFs (McNichol and Boadi, 2011). Rose (2008) documents considerable variation in RDF deposit and withdrawal rules across states. In terms of deposit rules, only seven states—including Alabama and Virginia—rely on a formula to determine the amount deposited in the state RDF each year. Sixteen states, including Connecticut and Oklahoma, make RDF deposits only when they have accumulated year-end surpluses. This deposit method prevents them from accumulating reserves in a steady and reliable way. In the other nine states, such as Kentucky and Ohio, the legislature has full discretion over RDF deposits through legislative appropriation, making RDF deposits more uncertain and subject to political manipulations. In terms of withdrawal rules, only two states, Indiana and Michigan, use a formula to determine how much money to withdraw from RDFs when they face negative income growth. Nineteen states, including Florida and Maine, allow RDF withdrawals only when they experience revenue shortfalls in the general fund. In the remaining 11 states, the legislature has full discretion over RDF withdrawals. As a result, state officials may withdraw funds before they are truly needed in order to create new current projects, to cover up administrative mishaps, or even for personal gain (Hou, 2013). In addition, states

Table A2
The estimated coefficients from the linear model of time for each state.
Source: U.S. Census Bureau Annual Survey of State Government Finances, the National Association of State Budget Officers.

State	t	Constant	Adjusted R-squared	P-value for the ADF test
AK	30	8546***	−0.03	0.06
AL	171***	11186***	0.79	0.74
AR	217***	5726***	0.91	0.68
AZ	307***	9976***	0.70	0.58
CA	2118***	101903***	0.60	0.36
CO	300***	8864***	0.80	0.48
CT	5	17335***	−0.05	0.24
DE	96***	3570***	0.83	0.58
FL	998***	31309***	0.75	0.79
GA	358***	17350***	0.48	0.86
HI	39***	6600***	0.36	0.04
IA	104***	9027***	0.75	0.22
ID	84***	3107***	0.66	0.38
IL	454***	32469***	0.61	0.40
IN	259***	16721***	0.62	0.01
KS	161***	6813***	0.77	0.24
KY	167***	11997***	0.54	0.74
LA	164***	12733***	0.48	0.71
MA	363***	24921***	0.57	0.41
MD	307***	15831***	0.90	0.31
ME	56***	4258***	0.50	0.81
MI	160	33749***	0.03	0.78
MN	275***	18031***	0.49	0.60
MO	176***	13158***	0.40	0.74
MS	150***	6309***	0.70	0.82
MT	57***	2182***	0.87	0.50
NC	587***	18455***	0.84	0.49
ND	89***	1767***	0.61	0.95
NE	84***	4620***	0.66	0.80
NH	61***	2049***	0.91	0.72
NJ	448***	29899***	0.65	0.07
NM	118***	6560***	0.65	0.22
NV	212***	3455***	0.85	0.57
NY	961***	67263***	0.72	0.05
OH	456***	30654***	0.66	0.69
OK	186***	8873***	0.88	0.07
OR	214***	9078***	0.64	0.39
PA	588***	35266***	0.69	0.52
RI	50***	3516***	0.68	0.48
SC	224***	9870***	0.85	0.83
SD	29***	1710***	0.87	0.38
TN	269***	10864***	0.71	0.46
TX	1354***	37483***	0.90	0.09
UT	241***	4796***	0.88	0.72
VA	559***	18202***	0.87	0.77
VT	34***	1966***	0.83	0.48
WA	297***	18792***	0.64	0.38
WI	214***	18410***	0.47	0.67
WV	137***	5164***	0.89	0.24
WY	70***	1743***	0.69	0.09
US	15230***	780962***	0.76	0.59

Note: State revenue is in millions of dollars. t=1,2,3, ..., 25.
* implies significance at 10 percent.
** implies significance at 5 percent.
*** implies significance at 1 percent.

Table A3
The estimated coefficients from the quartic model of time for each state.
Source: U.S. Census Bureau Annual Survey of State Government Finances, the National Association of State Budget Officers.

State	t	t^2	t^3	t^4	Constant	Adjusted R-squared	P-value for the ADF test
AK	1937	−274	13	−0	5588**	0.12	0.00
AL	441*	−18	1	−0	10047***	0.93	0.04
AR	237	17	−1	0	5136***	0.97	0.03
AZ	298	−5	2	−0	9413***	0.83	0.16
CA	−9926*	2042**	−109**	2*	113809***	0.81	0.01
CO	−374	157**	−10**	0**	8707***	0.92	0.05
CT	4722	−405	15	−0	−1562	0.27	0.06
DE	−125	49**	−3**	0**	3565***	0.94	0.01
FL	942	34	3	−0	28614***	0.93	0.03
GA	−753	292***	−18***	0***	15886***	0.93	0.10
HI	855***	−125***	7***	−0***	5217***	0.63	0.06
IA	86	41	−4**	0***	8418***	0.91	0.01
ID	369**	−18	1	−0	2023***	0.91	0.05
IL	-1520	479***	−32***	1***	32207***	0.87	0.06
IN	1288	−117	6	-0	13810***	0.74	0.00
KS	334	8	−2	0	5902***	0.81	0.14
KY	236	63*	−5***	0***	10179***	0.96	0.00
LA	−378	77	−3	0	13115***	0.81	0.01
MA	−655	262	−17*	0*	24051***	0.81	0.02
MD	−391	101*	−5	0	16814***	0.94	0.02
ME	−468***	79***	−4***	0**	4964***	0.89	0.02
MI	−3017***	778***	−51***	1***	32735***	0.91	0.01
MN	−1415**	391***	−25***	0***	18051***	0.88	0.05
MO	−508	194***	−13***	0***	12186***	0.90	0.10
MS	−394**	126***	−8***	0***	6248***	0.96	0.12
MT	165**	−19	1*	-0**	1976***	0.93	0.03
NC	−215	216	−14*	0*	17604***	0.92	0.10
ND	−32	21	−2**	0***	2256***	0.96	0.00
NE	125	15	−1	0	3986***	0.95	0.03
NH	−9	12	−1	0	2072***	0.97	0.00
NJ	1783	-184	12	-0	26342***	0.78	0.00
NM	172	3	−0	-0	6062***	0.74	0.05
NV	268	2	0	-0	2879***	0.93	0.07
NY	1094	−86	7	-0	68171***	0.68	0.05
OH	−441	228*	−13*	0	29519***	0.91	0.03
OK	−4	34	−2	0	8924***	0.91	0.00
OR	192	94	−8**	0**	7308***	0.90	0.06
PA	189	226	−16*	0*	32058***	0.91	0.01
RI	−305***	55***	−3***	0***	3993***	0.91	0.00
SC	193	8	0	−0	9538***	0.93	0.21
SD	35	4	−0	0	1589***	0.95	0.01
TN	793	−90	7	−0	9616***	0.82	0.09
TX	1928	81	−8	0	32667***	0.95	0.01
UT	77	36	−2	0	4574***	0.95	0.09
VA	-436	166*	−8	0	18846***	0.96	0.05
VT	-29	5	−0	−0	2094***	0.93	0.01
WA	1597***	−97	3	−0	14264***	0.92	0.13
WI	-908*	280***	−18***	0***	17924***	0.91	0.06
WV	232	−14	1	−0	4817***	0.95	0.00
WY	124	−35*	3**	−0**	2164***	0.89	0.00
US	-6481	5754	−348	6	750290***	0.91	0.08

Note: State revenue is in millions of dollars. t=1,2,3, ..., 25.
* implies significance at 10 percent.
** implies significance at 5 percent.
*** implies significance at 1 percent.

Table A4
The percentage of fiscally stressed periods with insufficient state RDFs if states had followed one of the two common rules of thumb between FY 1988 and FY 2012.

State	Number of fiscally stressed periods	If RDF balance before each fiscally stressed period were equal to	
		5% of general fund expenditure	15% of general fund expenditure
AK	7	85.7	71.4
AL	5	40.0	20.0
AR	5	60.0	20.0
AZ	4	75.0	50.0
CA	5	80.0	40.0
CO	6	66.7	33.3
CT	3	100.0	33.3
DE	7	57.1	0.0
FL	5	80.0	40.0
GA	3	100.0	0.0
HI	4	100.0	25.0
IA	6	50.0	0.0
ID	6	66.7	33.3
IL	4	75.0	25.0
IN	7	71.4	14.3
KS	6	50.0	33.3
KY	6	50.0	0.0
LA	6	66.7	16.7
MA	4	100.0	0.0
MD	6	50.0	0.0
ME	5	80.0	0.0
MI	4	75.0	25.0
MN	5	60.0	0.0
MO	5	60.0	20.0
MS	4	75.0	25.0
MT	6	66.7	16.7
NC	4	75.0	25.0
ND	9	55.6	22.2
NE	5	60.0	0.0
NH	6	66.7	0.0
NJ	6	66.7	16.7
NM	6	66.7	16.7
NV	5	60.0	60.0
NY	6	50.0	16.7
OH	5	60.0	0.0
OK	6	83.3	16.7
OR	6	66.7	50.0
PA	5	60.0	20.0
RI	5	80.0	0.0
SC	5	60.0	0.0
SD	7	42.9	0.0
TN	5	60.0	40.0
TX	5	80.0	0.0
UT	5	60.0	20.0
VA	5	60.0	0.0
VT	7	42.9	14.3
WA	6	50.0	0.0
WI	4	75.0	0.0
WV	7	57.1	0.0
WY	8	100.0	75.0
US	6	50.0	0.0

Note: We assume that states had accumulated these hypothetical RDF balances before each fiscally stressed period following one of the two common rules of thumb. Then, we compare these hypothetical RDF balances with the needed RDFs calculated from the HP filter to determine whether they would be sufficient for the fiscally stressed periods. The period for Connecticut is from FY 1993 to FY 2012.

differ in the fraction of lawmakers required to approve RDF withdrawals. Nine states, including South Carolina and Texas, require approval from a supermajority of the legislature, making it very difficult to access RDFs when they are actually needed. This further discourages states from saving more in RDFs.

Second, policymakers face political pressure not to accumulate large reserves (Mattoon, 2003). Compared to politically popular priorities such as cutting tax rates and increasing expenditures, the electoral reward for saving is relatively small. It also may be more politically convenient for states to cut local aid budgets or higher education funding in response to fiscal stress than to increase RDFs. In addition, current officials may be afraid that future political rivals will exploit these saved funds if they are elected. Therefore, some current officials would rather spend the money today towards their own goals instead of contributing to the RDFs for later use (Galle and Stark, 2012).

Third, some states may not value the stability of tax rates and expenditure as much as others (Gold, 1995). Therefore, they have less incentive to accumulate sufficient RDFs as a cushion against fiscal crises.[40] Last, there may be information constraints. Policymakers may not realize how much savings they are likely to need. This paper should help to fill such an information gap.

7. Conclusion

We show that the linear time model, which is the standard approach in the literature, has serious flaws and should not be used to estimate the short-term revenue component associated with business cycles. We provide evidence that the HP filter provides a more plausible estimate of the short-term revenue component and the needed RDFs than the other methods that we tried.

The size of the needed RDF is found to vary across states. Thus, there is no "one-size-fits-all" RDF size. We derive some potential target RDF levels for each state based on the distribution of the needed RDFs.

We recommend two general principles for states to consider in choosing their RDF level. First, holding everything else equal, states with more volatile revenue and expenditure systems should consider having larger RDFs than states with more stable revenue and expenditure systems. The higher the state revenue and expenditure volatility, the larger the budget shortfall states could face during recession, which requires a larger RDF to provide a budget cushion. Second, holding everything else equal, states that have stronger preference for stable tax rates and expenditure systems should consider adopting a higher RDF target than states that have weak preference for tax rate and expenditure stability. Voters reveal their preference for tax rate and expenditure stability by supporting legislature and gubernatorial candidates whose policy platforms on tax and expenditure match their preferences.

Our analysis shows that existing RDF caps are often lower than the needed RDFs. Many states, especially those with a cap below the median needed RDF, may consider removing or raising their cap, if possible, to a level more in line with their maximum needed RDF. In addition, we find that states often did not have sufficient reserves in their RDFs to deal with fiscally stressed periods. They may consider saving more in order to be better prepared for future economic downturns. To ensure that these savings are realized, state legislators may consider implementing a deposit formula, rather than leaving the contributions to political discretion (Hou, 2004; Rose, 2008).

Our findings have important implications for the proposals for a national state RDF. Mattoon (2003) and Elder and Wagner (2013) suggest that states pool their RDF reserves to take advantage of the fact that state-level business cycles are not in perfect sync with each other and therefore risks of revenue shortfalls can potentially be shared among states.[41] Mattoon (2003) proposes creating a national state RDF based on an unemployment insurance compensation trust fund model. To prevent states from gaming the system, an experience rating should be established to determine each state's contributions to the national state RDF. The experience rating can be based on the volatility of each state's revenue and expenditure system or on each state's frequency of withdrawal from the national RDF. The withdrawal rule should be based on an economic test including real revenue decrease, unemployment increase, or income decline. Also, like the unemployment insurance trust fund, the national state RDF should allow a member state to borrow money, with interest, from the fund after the state depletes its entire reserve.

This paper shows that simply pooling current state reserves would not be enough to address all states' revenue shortfalls. As Table 4 indicates, the United States as a whole had insufficient pooled state RDF reserves for two-thirds of the fiscally stressed periods in the last 25 years. Therefore, a sufficient national state RDF would require more savings from states than they have had historically.

Galle and Stark (2012) suggest that to encourage states to save more, the federal government should lower the costs of state savings by providing matching grants for state RDF contributions. The federal government could consider offering two forms of matching funds to cater to states with different degrees of political present bias. Present bias refers to the tendency to favor the present over the future. The first form of federal grants is unrestricted matching payouts. These would appeal to states with strong present bias, because they can immediately utilize these funds instead of saving them in the RDFs for future usage. The second form of federal grants is restricted matching contributions to state RDFs, which would appeal more to states with weak present bias. For each dollar of state contribution to RDFs, unrestricted federal matching grants should be a fraction of restricted federal matching contributions to state RDFs in order to help states to overcome present bias and accumulate more in their RDFs.

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Appendix A

See Appendix Figs. A1–A4.
See Appendix Tables A1–A4.

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[40] In theory, this preference could also cause states to choose a more volatile revenue structure, set a lower RDF cap, create unreliable deposit rules and strict withdrawal rules, or even fail to adopt an RDF, which further increases these states' fiscal instability. But in reality, states with more volatile tax bases do not necessarily place less weight on accumulating RDFs to smooth their budgets. For example, Alaska has a very volatile revenue structure, but also has one of the largest RDFs nationwide. As Table 4 shows, Alaska's RDF was sufficient to address revenue shortfalls from trend in nearly all of the fiscally stressed periods it experienced in FY 1988–FY 2012.

[41] We find that a sufficient national pooled state RDF for the fiscally stressed period associated with the Great Recession would be 13.4 percent lower than the total of the needed RDF of the 50 states saving individually. This is very close to the Elder and Wagner (2013) estimate that the cost saving of a national state RDF is about 13.1 percent at the 90 percent confidence level.

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