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Saving for a Rainy Day: Estimating the Appropriate 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, U.S. states have often found themselves exhausting their RDFs and having to raise tax rates or reduce expenditure while still experiencing a downturn. Therefore, how much each state should save in its RDF has become an increasingly important policy question. To address this issue, this paper develops target RDF levels for each U.S. state, based on the estimated short-term revenue component associated with business cycles and also on states' preferences for stable tax rates and expenditure. The analysis shows that in the last 25 years at least 21 states have never saved enough in their RDFs relative to their needed RDFs. The paper provides policy recommendations on reforming the RDF caps.

Keywords: rainy day funds, budget stabilization funds, revenue cyclicality
JEL codes: E32, E63, H71, H72

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I. 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 inelastic to the condition of the economy.[1] 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. 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). They 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

[1] Zhao and Coyne (2013) find that 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 income inelastic.

[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.

officially 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).[3] 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 often not completely eliminating states' fiscal stress (for example, Knight and Levinson 1999, Sobel and Holcombe 1996b, Douglas and Gaddie 2002, Wagner and Elder 2005, Hou 2005 and 2006).[4]

Various policy groups, regardless of their political affiliations, recommend establishing an RDF as a sound financial management technique (Henchman 2012 and 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.[5] 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 and 2013, McNichol and Boadi 2011, NASBO 2013, Pew Charitable Trusts 2014). On the other hand, maintaining a large RDF incurs opportunity costs and creates 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).

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[3] 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."

[4] 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.

[5] 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, and Wagner and Elder 2005).

Policymakers may be less careful about expenditure planning when having a large RDF, because they 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. Therefore, this paper seeks to determine the appropriate size of each state's RDF. To do so, we follow the principle suggested by Gold (1995) that the appropriate RDF size should depend upon both the volatility of each state's revenues and the desirability of having stable tax rates and expenditure growth. In addition, 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.

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. 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. Furthermore, we show that in the last 25 years at least 21 states have never saved enough in their RDFs relative to their RDF needs.

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 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 short-term revenue component. Third, this paper covers each of the 50 states and the United States as a whole, while 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 explicitly incorporate the preferences of state policymakers by providing a set of choices on RDF size. Finally, we provide policy recommendations on reforming state RDF caps and discuss the implications of our results for the proposals for a national state RDF.

II. 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 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, 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).

III. Data

This paper uses a newly constructed dataset to estimate an appropriate size of the rainy day fund for each of the 50 states. Because not only economic factors but also changes in state policies can affect state revenue, we need to develop a new measure of own-source revenue that each state would have collected in each year if the state had not enacted policy changes in that year.

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, which includes all state taxes (with small adjustments for several states), current charges, and miscellaneous revenues.[6] The latest data available from this survey are for FY 2012.

The second data source is the National Association of State Budget Officers (NASBO)'s annual Fiscal Survey of States. Since FY 1988, this survey has reported each state's 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.[7] If NASBO reported a revenue increase 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 decline for a state due to newly enacted policy actions, we add back the decrease amount.

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[6] We exclude state property taxes 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 selected 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. Following the literature, we also exclude intergovernmental revenue, which is mostly in the form of federal grants. It is widely 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. Thus, it is more plausible for states to design an RDF policy that ignores federal grants.

[7] The NASBO survey does not ask about revenue changes resulting from policy actions enacted in previous years, likely because most states do not estimate it. Due to this data limitation, we are unable to remove the impact of previous policy changes on current state revenue. This could introduce a downward bias in our estimates of the short-term revenue component, resulting in conservative estimates of appropriate RDF sizes.

Previous research does not make such an adjustment for policy changes. Therefore, it likely suffers a downward bias in estimating the short-term revenue component, because 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).[8]

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).[9] This time span covers three national recessions: the 1990–1991 recession, the 2001 recession, and the 2007–2009 Great Recession. Owyang, Piger, and Wall (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.

IV. Methodologies for estimating the short-term revenue component

This paper applies several new methodologies 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.[10] 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

[8] Using the results from a linear time model for the entire nation as an example, Appendix Figure 1 shows that the absolute size of the estimated short-term component based on the unadjusted state revenue is consistently smaller than the one based on the adjusted state revenue.

[9] 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.

[10] 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, Fox, and Tuttle 2006).

component. The long-term and short-term components are assumed to have different underlying operating determinants (Kuznets and Jenks 1961).

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.[11] 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, and *t=1, 2, 3, ..., T.* The functional form $f(.)$ may vary from state to state, and it may be linear or a quadratic polynomial, partly reflecting the fact that some states have a more progressive or regressive tax system than others. Therefore,

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

Appendix Table 1 shows the selected functional form $f(.)$ and estimated coefficients for each state.[12]

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[11] 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.

[12] 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.

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.[13]

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). Second, this 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, such as Connecticut and Hawaii, that are heavily dependent on capital gains tax or spending from out-of-state visitors have an adjusted R-squared of lower than 0.6 (see Appendix Table 1).

[13] 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-based method implicitly acknowledges the validity of other statistical approaches to separating the long-term component from the data.

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.

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, 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 2).

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, as 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 of the ADF test is above 0.1 for 42 states (Appendix Table 2). 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 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 3 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 3).[14]

Filtering

[14] 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.

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 approach—filtering—that does not require such a strong assumption. Unlike the linear and quartic time models, the filtering approach is able to obtain a short-term component that is always stationary. It is also more robust to outliers than the linear and quartic time models.[15]

The Hodrick-Prescott (HP) filter is the most commonly used filter in the economics field.[16] It extracts the long-term component τ_t from the data by solving the following optimization problem:

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

where λ is the smoothing parameter. Minimizing the first term penalizes the cyclical component, while minimizing the second term penalizes changes in the growth rate of the long-term component. The larger the value of λ, the higher the penalty in the second term and therefore the smoother the long-term component. The common practice is to set λ at 6.25 for annual data (Ravn and Uhlig 2002).[17]

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 final years of the sample period, which introduces another downward bias in

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[15] 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.

[16] 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.

[17] 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 $\lambda = 6.25$.

estimating the short-term component. Therefore, using the HP filter is likely to underestimate the absolute size of the negative short-term revenue component associated with the 2007–2009 Great Recession.

V. Determining the appropriate 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 (McGranahan and Mattoon 2012b, Gordon 2012). The preferred method based on these criteria will later be used to determine the appropriate RDF size for each state.

We first perform the comparison for the United States as a whole, as shown in Figure 1, which serves as a general case, and then for each of the 50 states, as shown in Appendix Figure 2. To make the estimated short-term revenue component relatively comparable across states, we divide it by the average of the nation's or each state's general expenditure over FY 1988–FY 2012, as shown in both figures.[18]

There are some similarities in the short-term revenue component estimated by different methods in Figure 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

[18] To further facilitate an across-state comparison, in Appendix Figure 2 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.

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. Combining these two 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 is opposite to most states' actual experience. The reason for this is that the linear time model is very sensitive to outliers. Thus, its regression line is 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 provides the most conservative 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 Figure 2). 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.[19] The income-based method shows no negative short-term revenue component for Kentucky and Louisiana around the 2001 recession and for Michigan and 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 *some* energy-producing states (for

[19] 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, Piger, and Wall (2005), whose analysis is based on the Federal Reserve Bank of Philadelphia's state-level coincident index.

example, Kentucky and Louisiana).[20] 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 also requires fewer assumptions and is more robust to outliers. It usually provides a more conservative estimate of the short-term revenue component than other methods, so we use it later to develop a conservative recommendation on the appropriate RDF size.

The quartic time model or the income-based method provides the second most conservative estimate. These can be used by states to gauge the sensitivity of the findings to model specification. 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 represents the amount of savings that a state would need before entering the fiscally stressed period in order to 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.[21] 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

[20] We run a linear regression of state revenue on personal income for Michigan (Appendix Table 1). 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.

[21] 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.

facilitate comparisons of needed RDF across states and comparisons of needed RDF with the RDF cap or balance within individual states.[22]

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 results in the addition of two or three fiscally stressed periods to the national recession-related fiscally stressed periods. Second, as Owyang, Piger, and Wall (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.

Following the recommendation of Gold (1995), we introduce a second factor in determining the appropriate 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. If a state has a strong preference for not raising tax rates or cutting spending 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 or spending

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

reductions during periods of unusually severe fiscal distress, it may want to set a lower target for its RDF. For example, a state that wishes to have 50 percent confidence in having sufficient savings to deal with any fiscally stressed period could choose the median of the needed RDFs across fiscally stressed periods as its target level.[23]

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 Figure 1 and Appendix Figure 2, the result from the HP filter is almost always the smallest for each state.[24] To further test the credibility of the result from the HP filter, we run a correlation across the 50 states 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.[25] We find that the correlation between the two is 0.5 and highly statistically significant with a p-value of less than 0.001.

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

[23] 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.

[24] 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.

[25] The correlation is expected to 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 identical periods.

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.

Table 2 shows the median of the needed RDFs during the FY 1988–FY 2012 period, which provides a more conservative target level. 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; the gap between the two is within one percentage point for 42 states.

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. 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 (2014), with a correlation of 0.4 that is significant at the 1 percent level.[26]

VI. 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).[27] These caps can negatively impact the effectiveness of the RDFs if

[26] 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.

[27] 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 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.

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). 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.

States 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 needed RDFs relatively comparable, we multiple 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.

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 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 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.[28] 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.[29]

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.

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

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[28] 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.

[29] 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.

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 percent of general expenditure.

Several factors can help to explain why states did not save enough in RDFs. First, states face institutional constraints (McNichol and Boadi 2011). As we have shown previously, most states have imposed an RDF cap lower than the needed RDF. Some states' deposit rules, such as only relying on general fund surplus, hinder states from accumulating reserves in a steady and reliable way. Some states also have strict withdrawal rules, such as supermajority requirements, which make 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). There are other competing, politically popular priorities, such as cutting tax rates and increasing pension contributions. 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.

Third, more fundamentally, 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. 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.

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 information gap.

VII. 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 any of the other methods that we tried.

This paper confirms that states experienced significant negative revenue fluctuations in economic downturns in the last 25 years, especially during the 2000s recessions. Therefore, RDFs have become an increasingly important and necessary countercyclical tool for states.

The size of the needed RDF is found to vary across states. Thus, there is no "one-size-fits-all," optimal RDF size. We derive some target RDF levels for each state based on the needed RDFs and states' preferences for stable tax rates and expenditure. By incorporating states' preferences, we provide them with more flexibility and, perhaps greater political feasibility.

The analysis shows that many caps that states have imposed on their RDFs are lower than the needed RDFs. Many states, especially those with a cap below the median needed RDF, may consider raising or removing their cap. In addition, we find that states often did not have sufficient reserves in their RDFs to deal with fiscally stressed periods.

Our results have important implications for the proposals for a national state RDF. Mattoon (2003) suggests 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.[30] This paper shows that simply pooling current state reserves would not be enough, because the United States as a whole had insufficient pooled RDF reserves for two-thirds of the fiscally stressed periods in the last 25 years. Therefore, a sufficient national RDF would require more savings from states than they have had historically.

Future research may incorporate considerations of expenditure cyclicality. State expenditure is cyclical because the caseload of public welfare and other social services increases

[30] We find that a sufficient national pooled 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 Wager (2013) estimate that the cost saving of a national RDF is about 13.1 percent at the 90 percent confidence level.

with the unemployment rate (McGuire and Merriman 2006). States spend different shares of their general expenditure on these services, and therefore may face different degrees of expenditure cyclicality and have different needs for smoothing out government spending over business cycles.[31] Additional research could cast light on the quantitative implications of these cyclical swings for needed RDFs.

[31] In FY 2012, spending on public welfare as a percentage of state general expenditure ranged from 15 percent for Wyoming to 38 percent for Tennessee, while the nationwide percentage of state general expenditure on public welfare was 30 percent in that year.

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Table 1. Maximum of the Needed RDFs during FY 1988 — FY 2012

(as a percentage of state general expenditure)

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

Source: Author's calculations

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

Table 2. Median of the Needed RDFs during FY 1988 — FY 2012

(as a percentage of state general expenditure)

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

Source: Author's calculations

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

Table 3. Comparing State RDF Caps with the Median and Maximum Needed RDFs

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

Source: McNichol and Boadi (2011), author's calculations

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

Table 4. The Percentage of Fiscally Stressed Periods with Insufficient State Savings

(FY 1988 — FY 2012)

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

Source: Author's calculations

Note: The needed RDFs are caculated 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 time period for Connecticut is from FY 1993 to FY 2012.

Table 5. Average Savings Deficiency for Fiscally Stressed Periods with Insufficient State Savings (FY 1988 — FY 2012, as a percentage of state general expenditure)

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

Source: Author's calculations

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 caculated 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.

Appendix Table 1. The Estimated Coefficients from the Income-based Model for Each State

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

Source: U.S. Census Bureau Annual Survey of State Government Finances, U.S. Bureau of Economic Analysis, the National Association of State Budget Officers

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.

Appendix Table 2. The Estimated Coefficients from the Linear Model of Time for Each State

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

Source: U.S. Census Bureau Annual Survey of State Government Finances, the National Association of State Budget Officers

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.

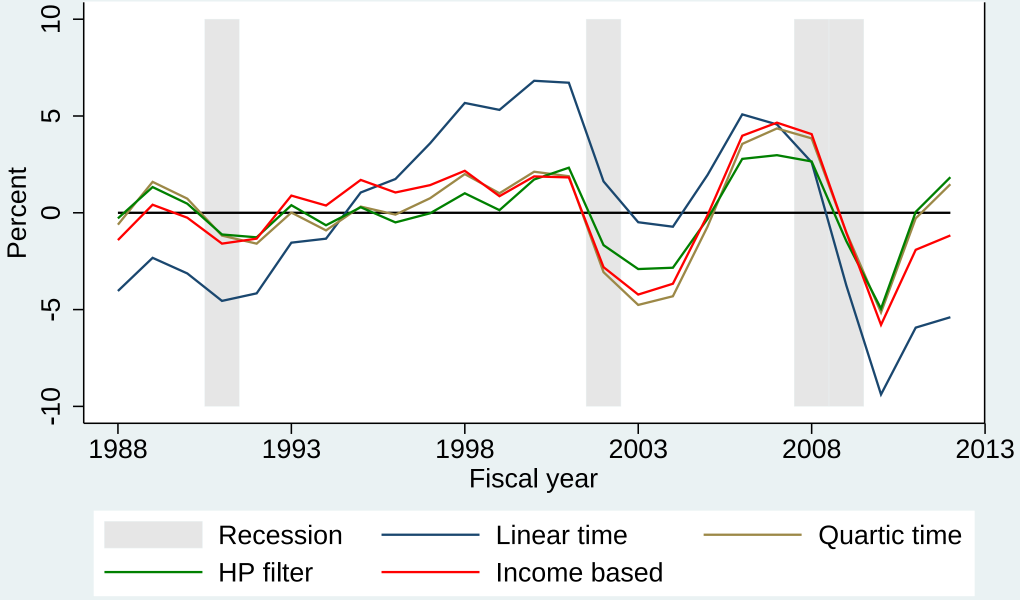
Appendix Table 3. The Estimated Coefficients from the Quartic Model of Time for Each State

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

Source: U.S. Census Bureau Annual Survey of State Government Finances, the National Association of State Budget Officers

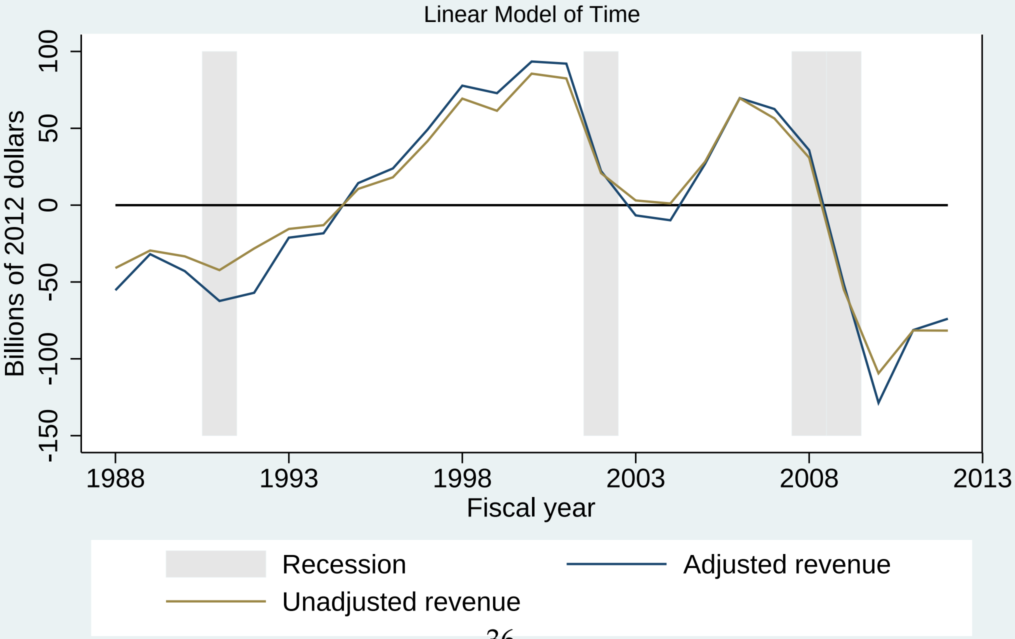
Note: State revenue is in millions of dollars. t=1,2,3, …, 25. * implies significance at 10 percent; ** implies significance at 5 percent; *** implies significance at 1 percent.

Figure 1. Estimated Short-term Component of State Revenue for the United States

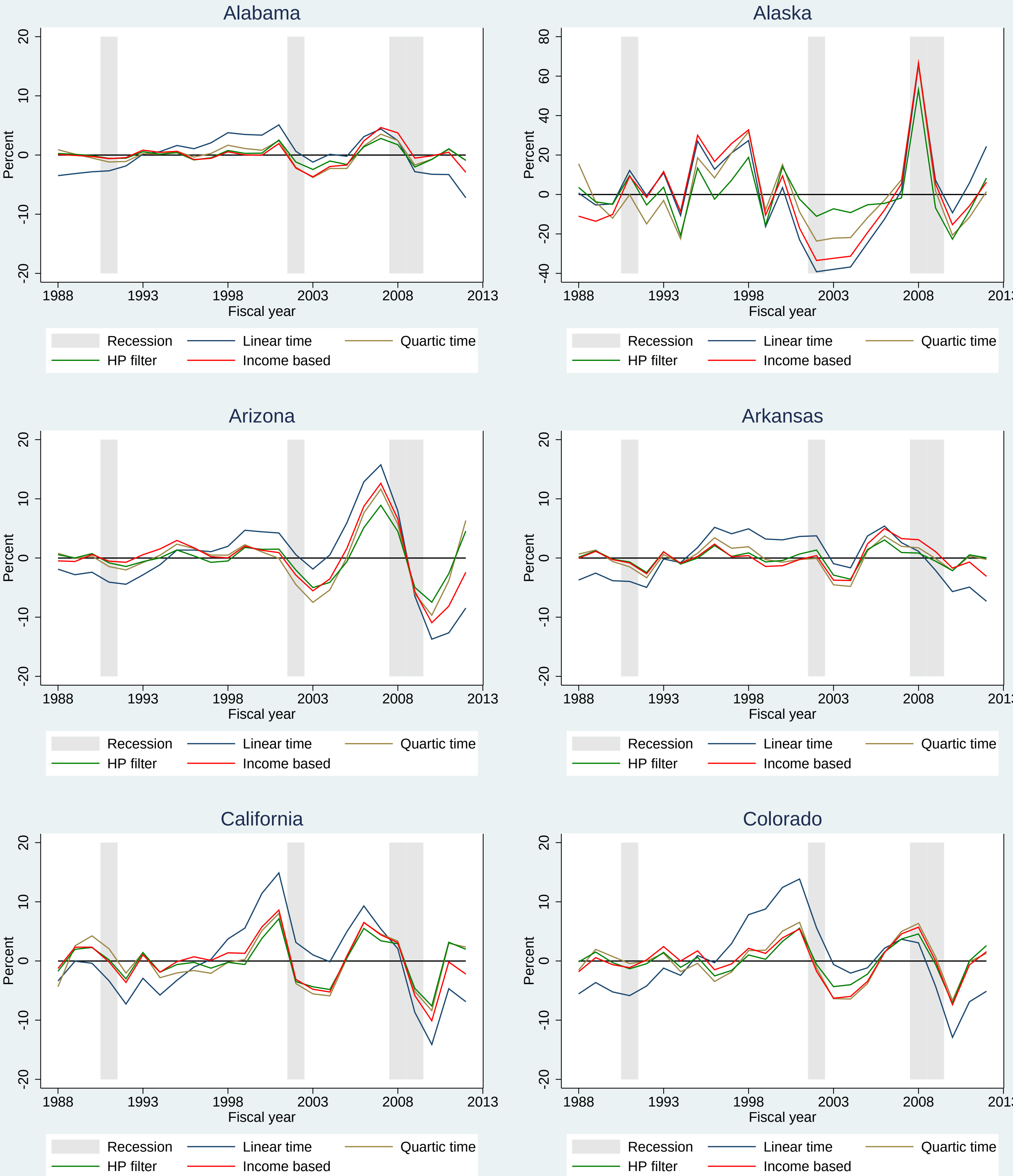


Note: The estimated short-term component of state revenue is presented as a percentage of the average of U.S. total state general expenditure from FY 1988 to FY 2012.

Appendix Figure 1. Estimated Short-term Component of State Revenue for U.S.

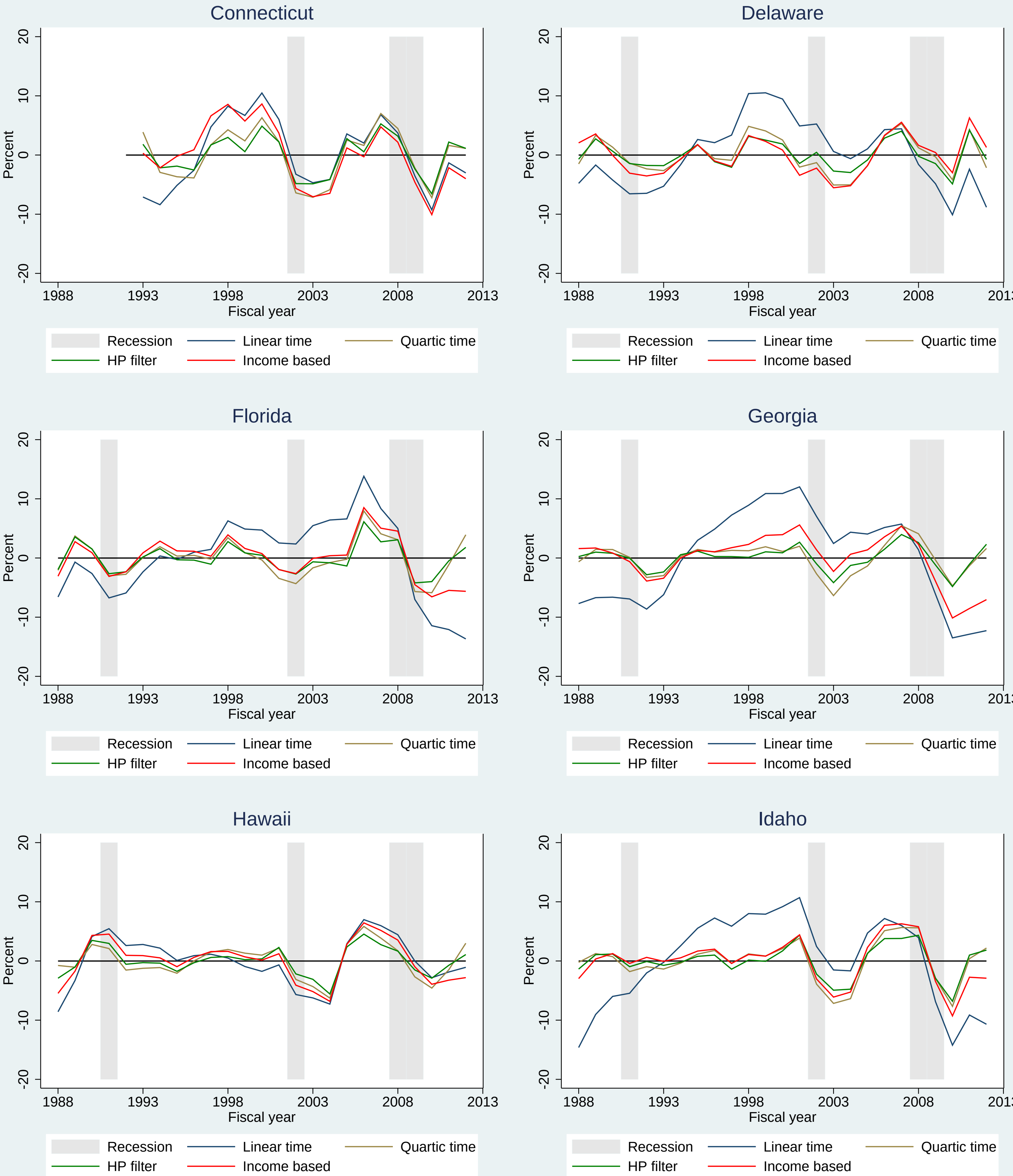


Appendix Figure 2. Estimated Short-term Component of State Revenue for 50 States and the U.S.



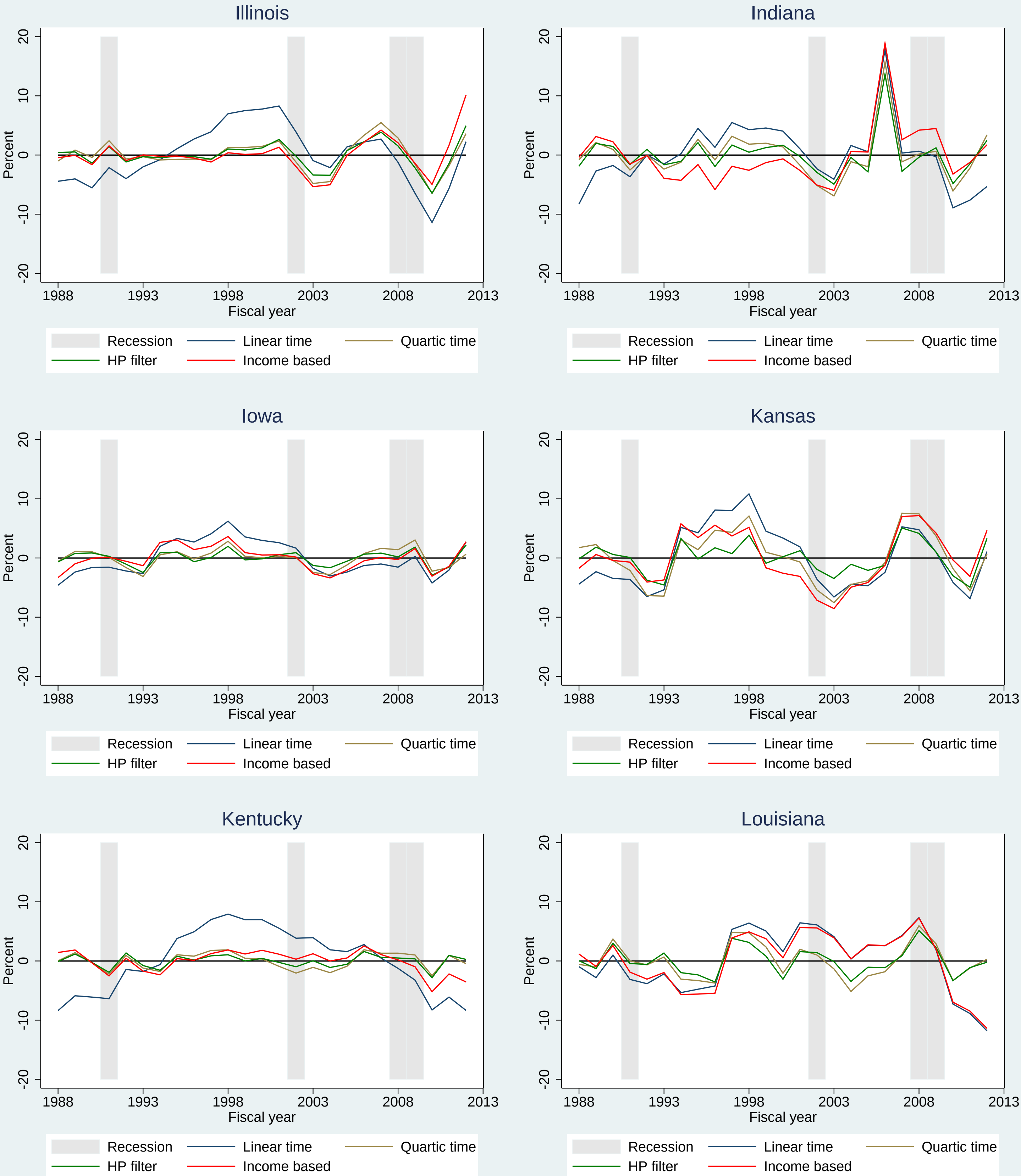
Note: The estimated short-term component of state revenue is presented as a percentage of each state's average general expenditure from FY 1988 to FY 2012.

Appendix Figure 2. Estimated Short-term Component of State Revenue for 50 States and the U.S. (Continued)



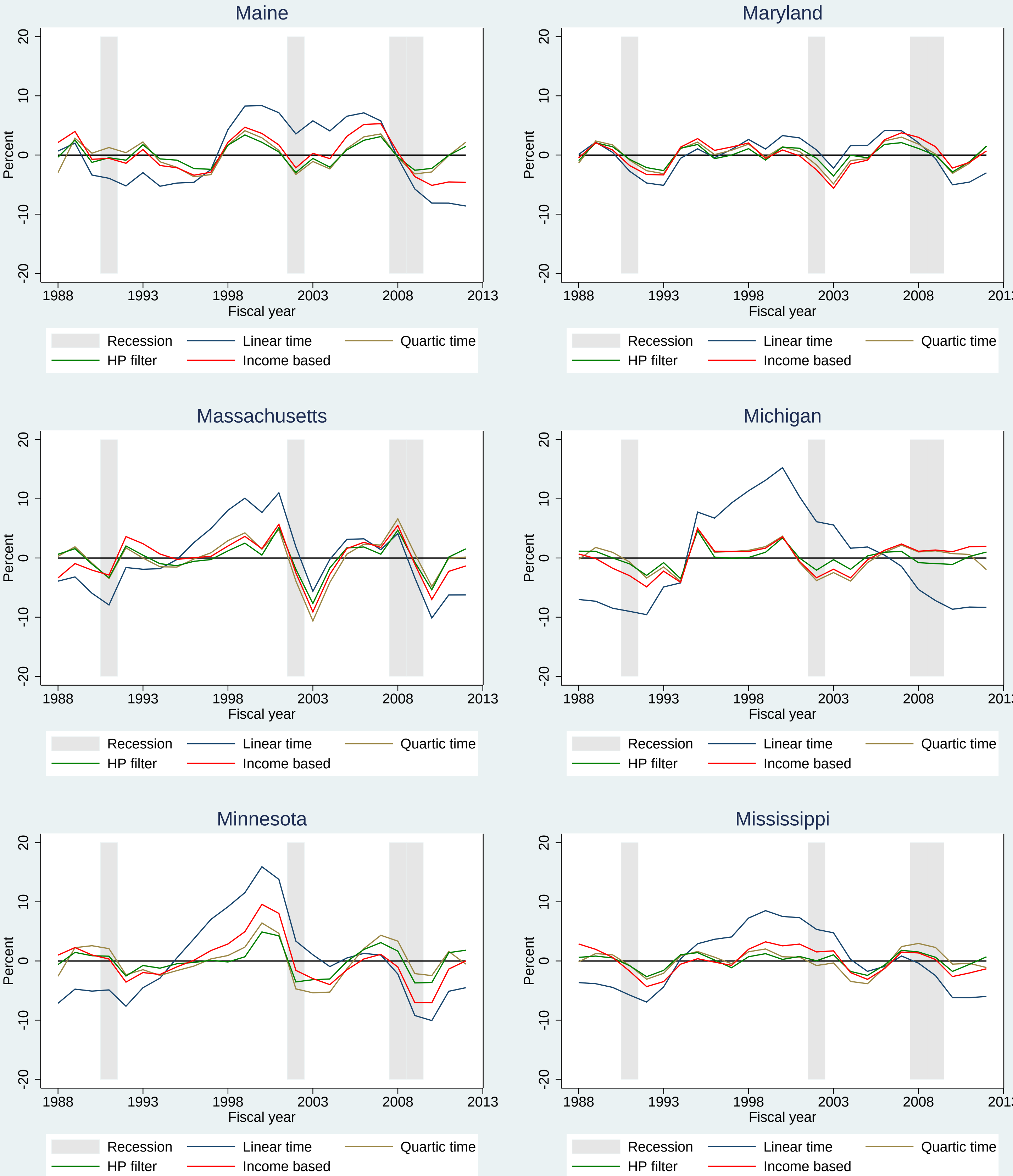
Note: The estimated short-term component of state revenue is presented as a percentage of each state's average general expenditure from FY 1988 to FY 2012.

Appendix Figure 2. Estimated Short-term Component of State Revenue for 50 States and the U.S. (Continued)



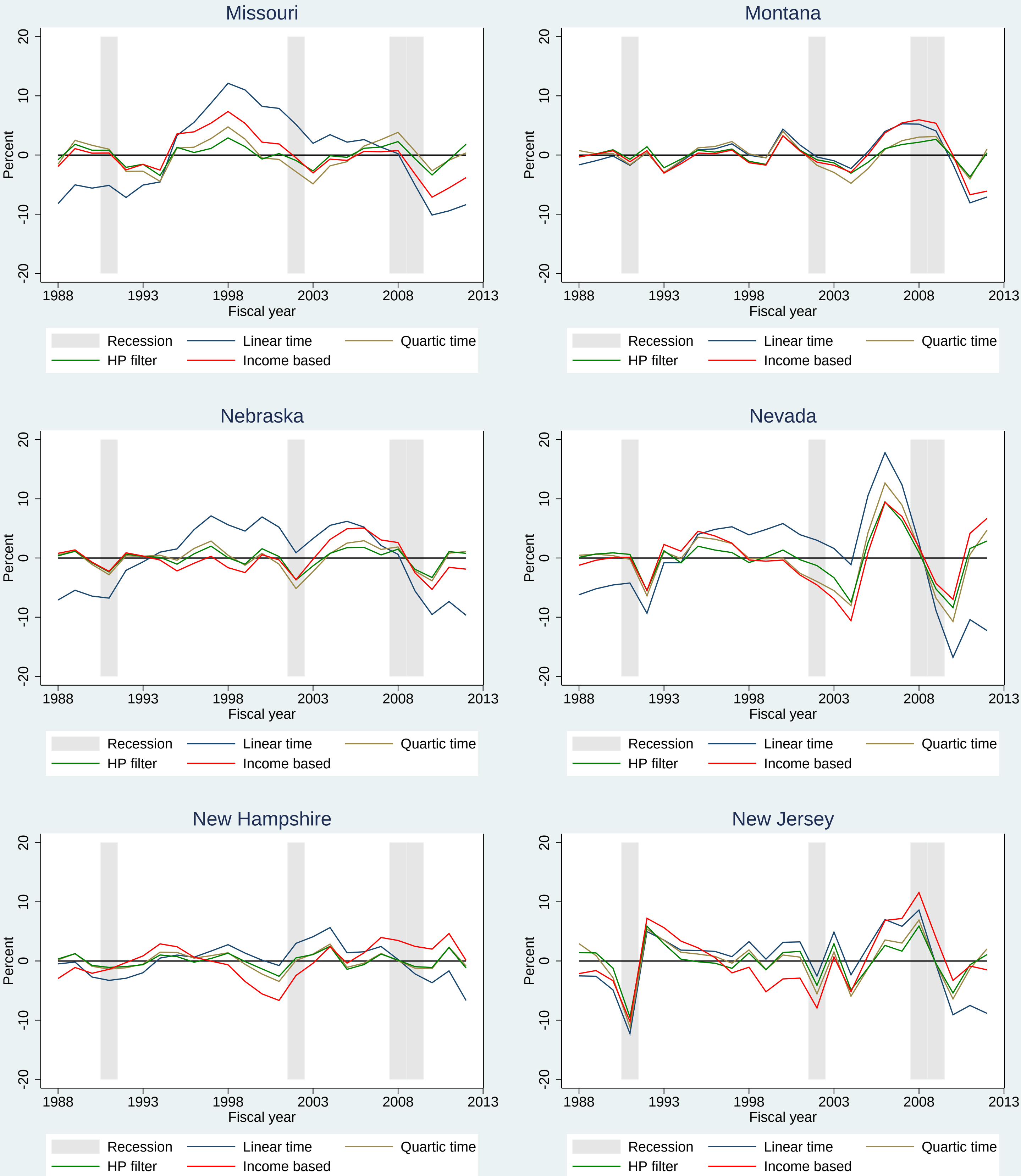
Note: The estimated short-term component of state revenue is presented as a percentage of each state's average general expenditure from FY 1988 to FY 2012.

Appendix Figure 2. Estimated Short-term Component of State Revenue for 50 States and the U.S. (Continued)



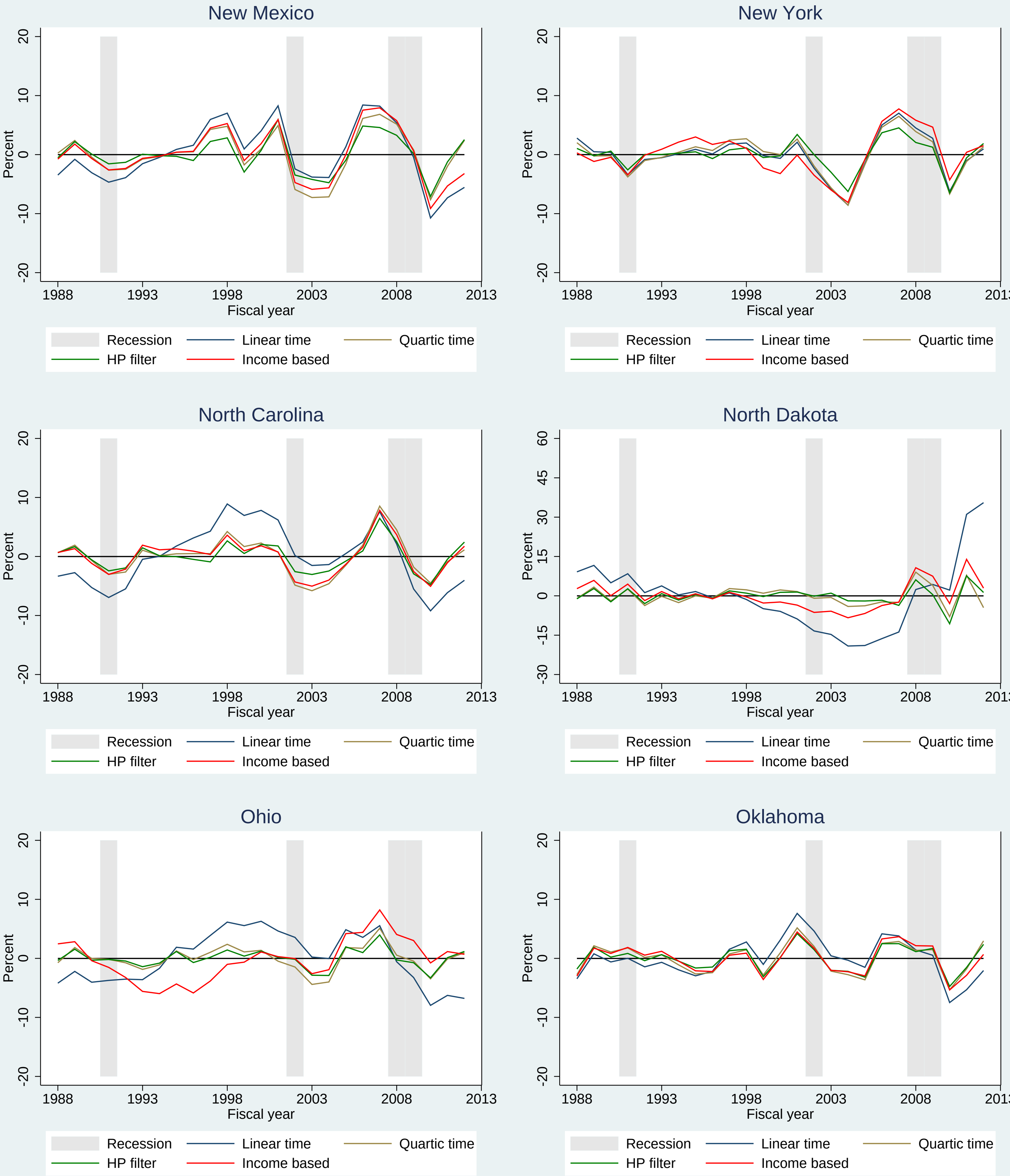
Note: The estimated short-term component of state revenue is presented as a percentage of each state's average general expenditure from FY 1988 to FY 2012.

Appendix Figure 2. Estimated Short-term Component of State Revenue for 50 States and the U.S. (Continued)



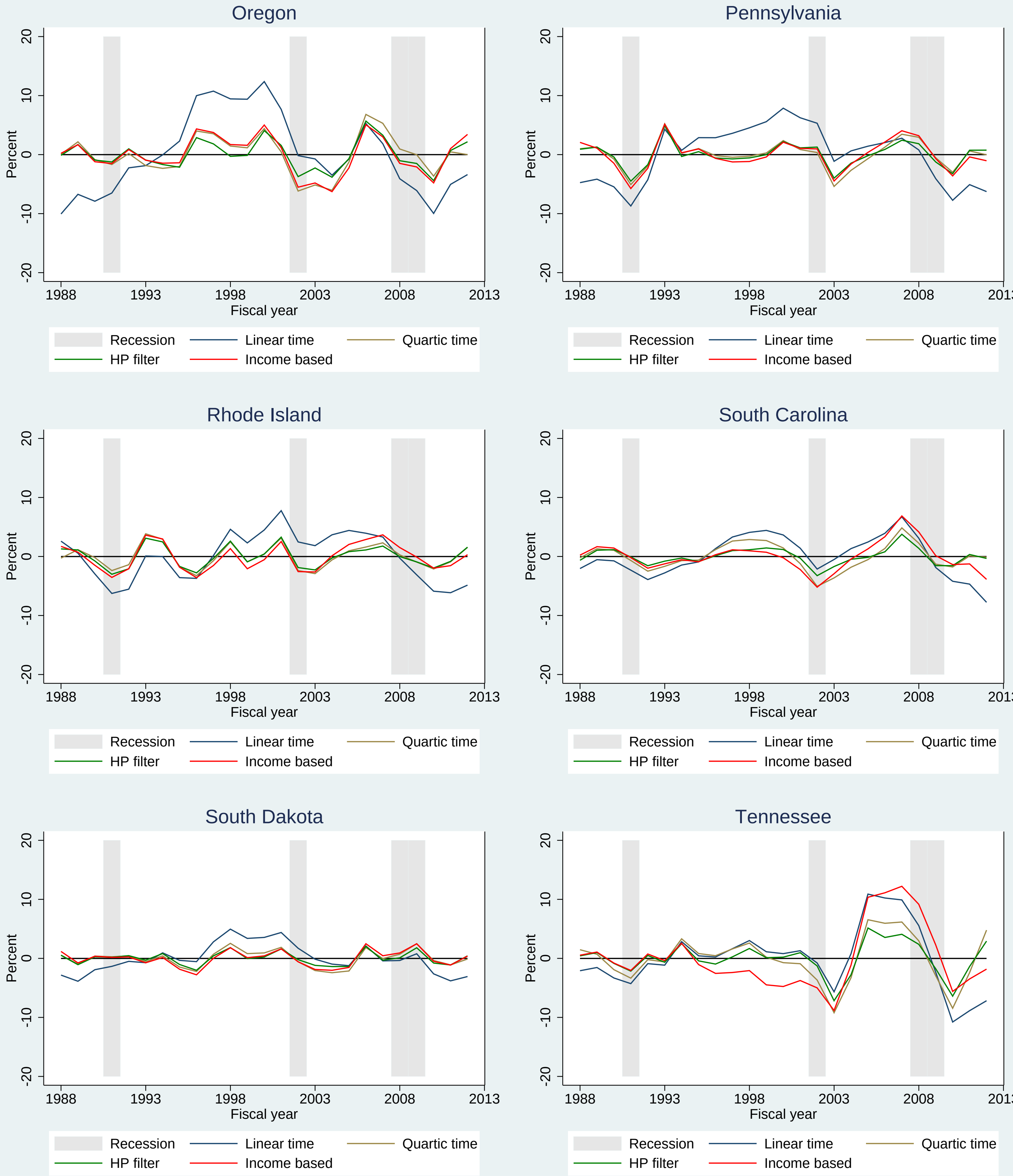
Note: The estimated short-term component of state revenue is presented as a percentage of each state's average general expenditure from FY 1988 to FY 2012.

Appendix Figure 2. Estimated Short-term Component of State Revenue for 50 States and the U.S. (Continued)



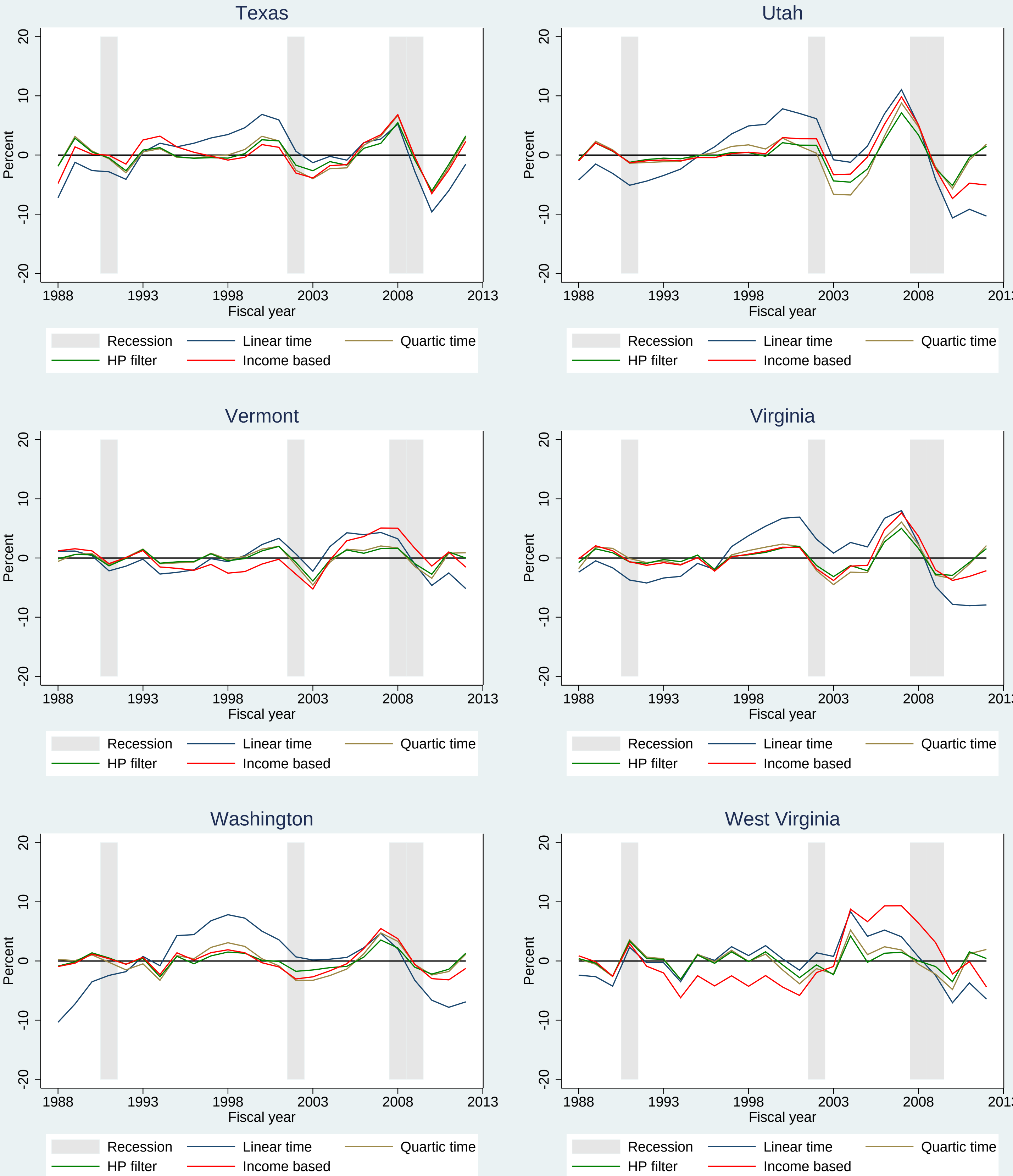
Note: The estimated short-term component of state revenue is presented as a percentage of each state's average general expenditure from FY 1988 to FY 2012.

Appendix Figure 2. Estimated Short-term Component of State Revenue for 50 States and the U.S. (Continued)



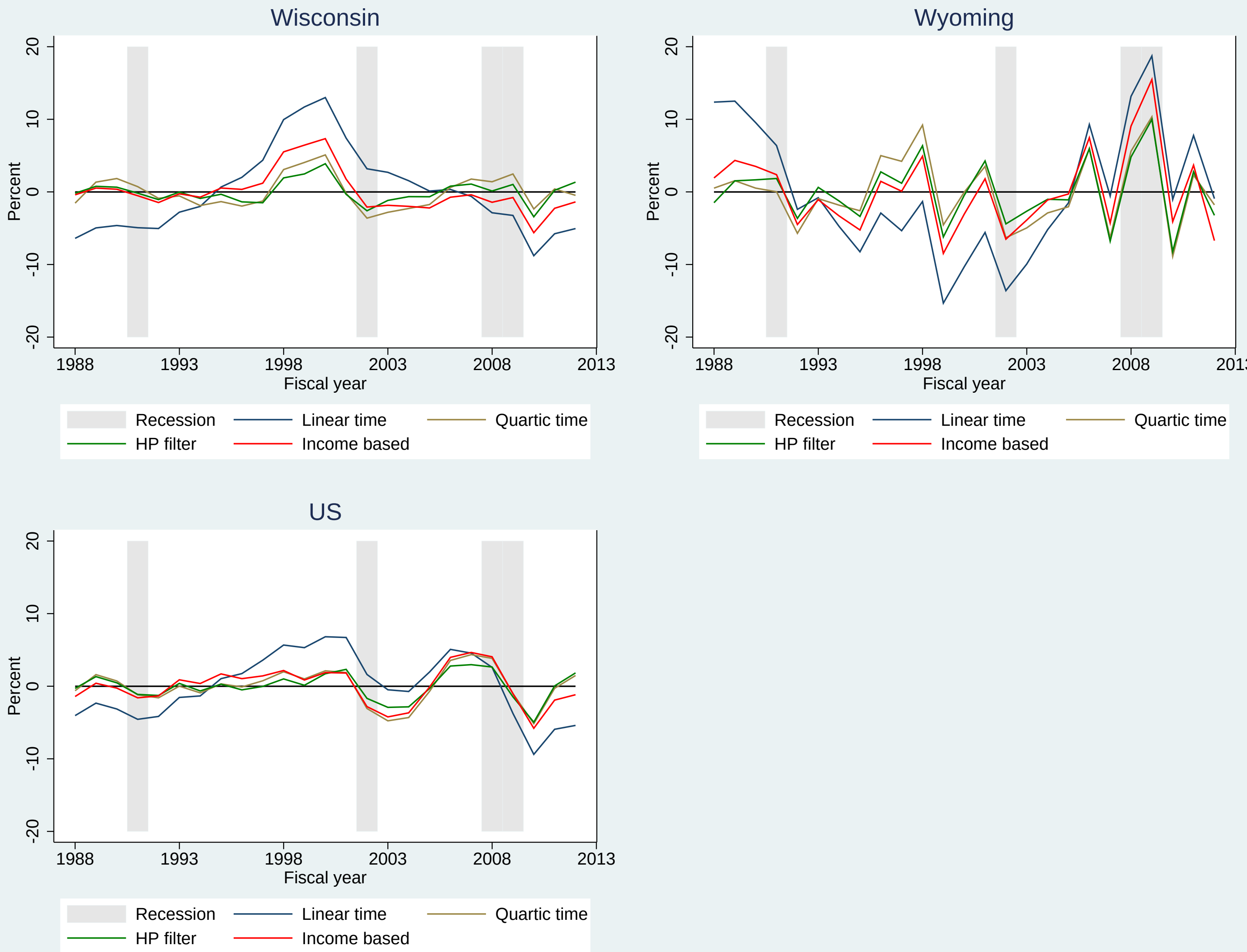
Note: The estimated short-term component of state revenue is presented as a percentage of each state's average general expenditure from FY 1988 to FY 2012.

Appendix Figure 2. Estimated Short-term Component of State Revenue for 50 States and the U.S. (Continued)



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.

Appendix Figure 2. Estimated Short-term Component of State Revenue for 50 States and the U.S. (Continued)



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.