How Well Are the States of the Eighth Federal Reserve District Prepared for the Next Recession?

Gary A. Wagner and Erick M. Elder

Economic downturns often force state policymakers to enact sizable tax increases or spending cuts to close budget shortfalls. In this paper the authors make use of a Markov-switching regression model to empirically describe the expansions and contractions in the states of the Eighth Federal Reserve District. They use the estimated parameters from the switching regressions to form probability distributions of the revenue shortfalls states are likely to encounter in future slowdowns. This allows them to estimate the probability that each state's projected fiscal-year-end balances will be sufficient to offset the fiscal stress from a recession. (JEL E6, H7)

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Economic downturns often force state policymakers into difficult financial positions because of the procyclical nature of tax bases and the countercyclical nature of government spending. Because of the fiscal institutions that exist in many states (such as balanced budget rules and borrowing restrictions), policymakers' options for mitigating periods of fiscal stress are effectively limited to the use of reserve balances, spending reductions, and tax increases.

In this paper we follow Wagner and Elder (2006) and use a Markov-switching regression model to empirically describe the expansions and contractions in states of the Eighth Federal Reserve District.[1] Using the estimated parameters, we form probability distributions of the revenue shortfalls states are likely to encounter during the next downturn. Based on fiscal-year-end projections for 2007, we then estimate the probability that each state's reserve balances will be sufficient to offset the fiscal stress from a recession. In other words, we estimate the probability that each state in the Eighth Federal Reserve District will be able to avoid spending reductions or tax increases if a recession were to begin in 2007.

In the following sections of the paper, we review previous research, outline our empirical methodology and findings, and offer concluding remarks.

STATE FISCAL CRISES AND "OPTIMAL" RAINY DAY FUNDS

An Overview of State Fiscal Crises and Policy Options

Although many factors contribute to periods of state fiscal pressure, the cyclical variability of revenue streams is generally considered to be the

[1] The Eighth District states are Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee.

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primary cause of fiscal crises (Holcombe and Sobel, 1997; Crain, 2003). Most state tax bases, including the primary bases of retail sales and wage and salary income, tend to be strongly procyclical. This means that revenue growth from these sources expands more rapidly than a state's economy during expansions and contracts more severely during downturns. Given the difficulty of forecasting recessions, state policymakers often find themselves in situations in which revenue is insufficient to match expenditure demands.

Policymakers normally rely on spending reductions, tax increases, and reserve balances accumulated during periods of revenue growth (or savings) to help mitigate unexpected budget shortfalls. Although the use of savings has expanded in recent decades, with nearly all states having a formal "rainy day" or budget stabilization fund to institutionalize the process, spending reductions and tax increases constitute the majority of state fiscal adjustments made during recessions. Following the 2001 national recession, for instance, the National Association of State Budget Officers (NASBO) reported that states increased taxes by nearly $18 billion during fiscal years 2002 though 2004 and also reduced budgeted spending by nearly $30 billion over the same period.[2] Moreover, states used more than $9 billion in reserve balances during this period to help close budget gaps, which is considerably more than the $1 billion in savings tapped during the 1990-91 downturn (Holcombe and Sobel, 1997).

States in the Eighth Federal Reserve District were not immune to the difficult times associated with the 2001 recession. Table 1 reports the tax and spending adjustments for each state in the Eighth District for fiscal years 2002 through 2004.

Eighth District states increased taxes by nearly $3.3 billion from 2002 through 2004, with all of the increases occurring in fiscal years 2003 and 2004. Three states—Illinois, Indiana, and Tennessee—accounted for more than 95 percent of the tax increases in the District. Arkansas, Kentucky, and Missouri made modest tax adjustments, while Mississippi was the only state in the District to avoid tax increases during the slowdown.

On the expenditure side, Illinois, Indiana, and Missouri were responsible for more than 80 percent of the District's after-budget adjustments. Most of these spending cuts occurred in 2002 and 2003, with only Illinois and Indiana making changes in 2004. Tennessee had the smallest expenditure adjustments during the recession, with $64 million in cuts in 2003.

Across the nation, states relied more heavily on spending adjustments than tax increases (roughly 60-40) during the 2001 downturn. In the Eighth District, however, only Arkansas, Illinois, and Indiana had a mix of tax increases and spending reductions that approximated the adjustments in the rest of the country. Kentucky, Mississippi, and Missouri relied almost exclusively on spending cuts, whereas Tennessee relied almost entirely on tax increases.

"Optimal" Rainy Day Funds

To assess how "prepared" states may be in future recessions, it is necessary to quantify the fiscal stress that states are likely to experience during a downturn. Previous studies have addressed this issue from the point of view of an "optimal" rainy day fund: If a state typically experiences fiscal stress equal to, say, 12 percent of the budget during a downturn, then savings equal to this amount would be sufficient to eliminate the need for spending cuts and tax increases throughout the slowdown.[3]

Early attempts to estimate the fiscal stress that states experience, such as Pollock and Suyderhoud (1986), Sobel and Holcombe (1996), and Navin and Navin (1997), did so by examining the cumulative deviation in the series of interest (either revenues or revenues plus expenditures) from a

[2] Given that the spending figures reported by NASBO do not account for spending reductions that occurred at the time state budgets were initially adopted, the aggregate reduction in state spending due to the recession is potentially much larger than $30 billion. For a more detailed analysis of the 2001 recession on state fiscal health, see Garrett and Wagner (2004).

[3] The use of savings to insure against unexpected budget shortfalls has several advantages over the use of spending cuts and tax increases. First, expenditure reductions and tax increases are unpopular among voters and therefore may be politically costly for policymakers. Second, the use of savings is an expansionary policy, whereas expenditure reductions and tax increases are contractionary policies. See Wagner and Elder (2005) for an overview on the effectiveness of state rainy day funds and reserve balances.

Table 1

Fiscal Adjustments of Eighth District States Due to 2001 Recession (in millions of current dollars)

	2002	2003	2004	Total
Tax adjustments				
Arkansas	–2.3	0	109.3	107
Illinois	0	370	828	1,198
Indiana	–5.9	1,002	2	998.1
Kentucky	0	0	8	8
Mississippi	0	0	0	0
Missouri	–24.5	72.5	0	48
Tennessee	0	933.2	0	933.2
Eighth District total	–32.7	2,377.7	947.3	3,292.3
Total all states	303.8	8,018	9,550	17,871.8
Spending adjustments (made after budget enactment)				
Arkansas	171	73	0	244
Illinois	500	202	1,320	2,022
Indiana	468.7	345.7	60	874.4
Kentucky	231.5	90.1	0	321.6
Mississippi	150.6	47.8	0	198.4
Missouri	750	304.7	0	1,054.7
Tennessee	0	64	0	64
Eighth District total	2,271.8	11,27.3	1,380	4,779.1
Total all states	13,668	11,752	3,488	28,908

SOURCE: Various issues of *Fiscal Survey of the States*, National Association of State Budget Officers.

linear trend. For example, Sobel and Holcombe (1996) summed the cumulative shortfalls in expenditures and revenues from their respective trends from 1989 to 1992 and found that the average state would have needed reserves equal to 30 percent of expenditures to maintain trend expenditures and revenues during the 1990-91 recession. Examining individual states over a longer period, Pollock and Suyderhoud (1986) and Navin and Navin (1997) find that savings equal to 11 percent and 13 percent of the budgets in Indiana and Ohio, respectively, would be sufficient to offset a normal downturn.

Although Pollock and Suyderhoud (1986), Sobel and Holcombe (1996), and Navin and Navin (1997) provide only point estimates of state fiscal stress, it is possible to form probability distributions of state expansions and contractions using a linear-trend approach. This would allow one not only to estimate a distribution of shortfalls that states are likely to experience, conditional on past recessions, but also to calculate how much states would need to save during expansions to insure against those possible shortfalls that a state may experience. However, using a linear-trend approach to form these distributions has a serious shortcoming because the parameters from a linear-trend model are chosen to minimize the deviation from trend rather than to best describe the distribution of expansions and contractions in the data. In other words, if expansions are defined as periods above trend and contractions are defined as periods below trend, then there is no reason to believe that the expansions and contractions identified from a linear-trend model will correspond to actual business cycles.[4]

A recent paper by Wagner and Elder (2006) attempts to overcome this limitation by identifying state economic cycles using a Markov-switching regression model. The model explicitly assumes that a data series can be characterized by a series of distinct regimes (such as expansions and contractions), and recent work by Li, Lin, and Hsiu-hua (2005) suggests that the model performs very well in accurately identifying business cycle turning points. Estimation involves jointly determining the parameter values describing each regime that best fit the observed data. These parameters include an estimate of the mean growth rate of each regime, as well as the probabilities that a given observation came from either an expansion or contraction regime, which are known as transition probabilities.

Wagner and Elder (2006) demonstrate how the estimated parameters from a Markov-switching regression model may be used to construct empirical probability distributions of state expansions and contractions. Forming these distributions for each state, Wagner and Elder (2006) find that the typical state's expected revenue shortfall is between 2.9 and 3.5 percent of revenue when the shortfall is measured relative to zero revenue growth, and between 13 and 16 percent of revenue when the shortfall is measured relative to the average rate of revenue growth during expansions. In addition, forming distributions of complete cycles that are based on the uncertainty in expansions and contractions, Wagner and Elder find that the average state should save between 0.5 and 2.5 percent of revenue during each expansion period to accumulate reserve balances sufficient to weather the next downturn without the need for tax increases or spending cuts.

[4] A related paper by Cornia and Nelson (2003) uses value-at-risk (VaR) to model the maximum budget shortfall that a state can expect to experience over a fixed time period. However, because VaR cannot model a data series as being generated by two (or more) probability distributions, such as expansions and contractions, it is impossible to form distributions of savings rates using VaR.

MARKOV-SWITCHING MODEL AND EIGHTH DISTRICT STATE BUSINESS CYCLES

Markov-Switching Model

The basic idea underlying regime-switching models is that many data series appear to be generated from multiple, distinct data-generating processes. As Hamilton (1994) notes, structural breaks or regime changes in a data series may be triggered by a variety of factors, including economic downturns, policy changes, and financial crises. If the regime changes are assumed to be predictable and known a priori, then they may simply be modeled using dummy variables. A more practical assumption is that the occurrence of such regime changes is unknown.

Econometric models featuring regime changes were first studied by Quandt (1958). Goldfeld and Quandt (1973) extended Quandt's simple switching model by allowing the data series to be generated by multiple regime switches that were governed by a Markov process so that the timing of the switches became dependent on the current regime in effect.

Although regime-switching regressions have a long history, they were not widely employed as a means of modeling business cycle movements until Hamilton (1989) extended Goldfeld and Quandt's model to include serially dependent data. Hamilton's model was a two-regime autoregression applied to the growth rate in real U.S. gross national product under the assumption that the regimes exogenously switched according to an unobserved Markov process. He found that not only did the model best fit the data when it identified distinct expansion and contraction regimes, but also that the changes between regimes closely matched the NBER recession turning points.

Although Markov-switching models have been widely used to examine aggregate data, they have only recently been applied to U.S. states. Owyang, Piger, and Wall (2005a) were the first to make use of the model and explored the extent to which state-level business cycles track the aggregate economy. Using Crone's (2002) monthly coincident index of state-level labor-market activity, they find that, while state cycles generally follow the aggregate economy, individual states may shift into an expansion or contraction before the national economy shifts, continue in an expansion as the national economy contracts, and experience a downturn that is not associated with an aggregate downturn. Moreover, Owyang, Piger, and Wall (2005a) find that expansion growth rates depend positively on the state's education and age composition, whereas recession growth rates depend on the state's industry mix.

Because state revenue data are published only annually and also include discretionary changes to both tax rates and tax bases, they are poorly suited for isolating state-level business cycle movements. As a result, we follow both Owyang, Piger, and Wall (2005a) and Wagner and Elder (2006) by using Crone's (2002) monthly coincident index as our measure of state-level economic activity over the period 1979:09–2007:01. As Owyang, Piger, and Wall (2005a) note, an advantage of Crone's (2002) index is that, unlike many state-level data series, it exhibits distinct business cycle movements at a high frequency. On the other hand, because the index is constructed from only labor market variables, it is not as broad a measure of economic activity as gross domestic or gross state product.

Denoting a state's monthly growth rate in the coincident index at time t as $\dot{y}_t$, the two-regime Markov-switching model may be expressed as

$$\begin{aligned} &\dot{y}_t = \mu_{S_t} + \varepsilon_t, \\ &\varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right), \\ &\mu_{S_t} = \mu_0 + \mu_1 S_t,\ \mu_1 > 0, \end{aligned} \tag{1}$$

where μ denotes the mean growth rate and ε_t is the error term at time t assumed to be normally distributed with variance σ_ε^2. The growth rate in (1) is assumed to switch exogenously between two regimes, and the switches are governed by an unobserved regime variable, $S_t = \{0,1\}$. When $S_t = 0$, which we refer to as the low-growth regime, $\dot{y}_t$ follows a stationary AR(0) process and is assumed to be generated by a normal distribution with a mean of μ_0. When S_t switches from 0 to 1, which we call the high-growth regime, $\dot{y}_t$ is presumed to have been generated from a normal distribution with a mean equal to $\mu_0 + \mu_1$. In short, the data-generating process for $\dot{y}_t$ is a mixture of two normal distributions having the same variance but potentially different means.

Although S_t is unobserved, its behavior is restricted to evolve according to a first-order, two-state Markov chain with the following transition matrix:

$$\begin{aligned} \mathbf{P} &= \begin{bmatrix} P\left(S_t = 0 \mid S_{t-1} = 0\right) & P\left(S_t = 1 \mid S_{t-1} = 0\right) \\ P\left(S_t = 0 \mid S_{t-1} = 1\right) & P\left(S_t = 1 \mid S_{t-1} = 1\right) \end{bmatrix} \\ &= \begin{bmatrix} P_{LL} & 1 - P_{LL} \\ 1 - P_{HH} & P_{HH} \end{bmatrix}, \end{aligned} \tag{2}$$

where P_{ij} is the transition probability of $S_t = i$, given that $S_{t-1} = j$. Hence, P_{HH} is the probability that economic activity is in the high-growth regime in period t, conditional on having been in the high-growth regime in period t–1. Placing restrictions on the behavior of S_t allows one to estimate the probability that economic activity is in an expansion (or contraction) regime in each time period, despite the fact that the underlying regime is assumed to be latent and unobservable.[5]

Markov-Switching Parameter Estimates for Eighth District States

The parameter estimates from each Eighth District state's Markov-switching regression are presented in Table 2. The expected duration of each regime, which is discussed in more detail below, is also presented.

Given that we are updating the specification used by Owyang, Piger, and Wall (2005a) and Wagner and Elder (2006) with more available data,

[5] We also follow Owyang, Piger, and Wall (2005a) and estimate the models using the Bayesian Gibbs-sampling approach developed by Kim and Nelson (1998). Our prior distributions were set equal to the priors of Owyang, Piger, and Wall (2005a), and the joint posterior distributions were simulated using 10,000 replications with an additional 2,000 burn-in replications. The mean parameters (μ_0 and μ_1) are assumed to be normally distributed with means of 1 and –1, respectively, and a covariance matrix that is equal to the identity matrix. The transition probabilities, P_{HH} and P_{LL}, have prior beta distributions given by $\beta(9,1)$ and $\beta(8,2)$, implying means of 0.9 and 0.8, respectively. For a more detailed description of the estimation procedure, see Kim and Nelson (1998) and Owyang, Piger, and Wall (2005a). We acknowledge use of the computer routines described in Kim and Nelson (1999).

Table 2

Markov-Switching Parameter Estimates

	$\hat{\mu}_0 + \hat{\mu}_1$	$\hat{\mu}_0$	$\hat{P}_{HH}$	$\hat{P}_{LL}$	$E[t_H]$	$E[t_L]$	$E[t_H] + E[t_L]$
Arkansas	0.334*	–0.082*	0.982	0.940	55.55	16.71	72.27
Illinois	0.362*	–0.239*	0.978	0.950	45.72	20.08	65.80
Indiana	0.337*	–0.386*	0.981	0.910	54.90	11.22	66.12
Kentucky	0.350*	–0.194*	0.980	0.936	51.82	15.72	67.54
Mississippi	0.341*	–0.075	0.975	0.930	41.19	14.45	55.65
Missouri	0.362*	–0.216*	0.980	0.941	50.48	17.12	67.61
Tennessee	0.389*	–0.057	0.979	0.936	49.40	15.79	65.20
Median	0.351	–0.194	0.980	0.937	50.48	15.79	66.28

NOTE: The reported parameters are the means of the posterior distributions; *denotes that the 90 percent highest posterior density interval does not contain zero; and $E[t_H]$ and $E[t_L]$ denote the expected duration of expansions and contractions, respectively.

our parameter estimates are very similar to the parameter estimates of these studies. The median expansion and contraction (monthly) growth rates across the Eighth District states are 0.351 and –0.194, respectively. However, as shown in the first column of Table 2, expansion growth rates range from a high of 0.389 in Tennessee to a low of 0.334 in Arkansas; recession growth rates, shown in column 2, vary from a low of –0.386 in Indiana to a high of –0.057 in Tennessee. There is considerably more variation in the average recession growth rates across the District than in the average expansion growth rates. In fact, three states in the District, Arkansas, Mississippi, and Tennessee, have average recession growth rates less than –0.10, whereas three states have recession growth rates in excess (more negative) of –0.20.[6]

The estimated transition probabilities for each state, P_{HH} and P_{LL}, demonstrate the persistence in each regime. Given an expansion in period t–1, our estimates indicate that the median state in the District has a 0.980 probability of expanding in period t. Similarly, the probability is 0.937 that a contraction in period t–1 will be followed by a contraction in period t. As Hamilton (1994) shows, the expected duration of regime j may be computed as $E[t_j] = (1 - P_{jj})^{-1}$ for $j = H,L$. (These figures are reported for each state in Table 2.) Although cycle durations vary noticeably, the median Eighth District state can expect to experience 50 months of expansion (denoted $E[t_H]$ in Table 2), followed by nearly 16 months of contraction (denoted $E[t_L]$ in Table 2), resulting in an expected business cycle of 66 months. The state with the longest expected expansion in the District, Arkansas, will on average experience continuous growth for one year longer than the state with the shortest expected expansion, Mississippi. Similarly, Illinois has the longest expected contraction in the District, at just over 20 months, which is 9 months longer than Indiana's shortest expected contraction.[7] Overall, the Markov-switching model identifies nearly 77 percent of the observations as expansions, suggesting that the normal regime for all states in the District is one of growth.

[6] See Owyang, Piger, and Wall (2005b) for a much more detailed analysis of the expansion growth rates, contraction growth rates, and regime turning points in Eighth District states.

[7] Although we do not report the estimated probability that a state is in an expansion at a given point in time (S_t), it is generally very clear whether a state is currently in an expansion or contraction regime. Owyang , Piger, and Wall (2005b) examine these probabilities in detail for Eighth District states, and the interested reader is referred to their paper.

EMPIRICAL DISTRIBUTIONS OF STATE SHORTFALLS AND SAVINGS RULES

Probability Distributions of State Revenue Shortfalls

The estimated parameters of the Markov-switching regressions provide measures of the duration and amplitude of state economic cycles. In this section of the paper we follow Wagner and Elder (2006) and use these parameters to form probability distributions of state revenue shortfalls.

Although states may experience fiscal pressure on both the expenditure and revenue sides of the budget, Kusko and Rubin (1993) note that revenue streams are far more sensitive to business cycle movements than expenditures. We therefore focus only on state revenue, implying that our estimates should be interpreted as the minimum fiscal stress that states are likely to experience during a downturn.

In addition, given that state tax bases tend to be more volatile than economic activity, we define φ as the elasticity of a state's total revenue growth with respect to the growth in the state's economy. Each state's high- and low-regime growth rates in revenue may therefore be expressed as $g_H = \varphi(\hat{\mu}_0 + \hat{\mu}_1)$ and $g_L = \varphi\hat{\mu}_0$, respectively. The use of an elasticity allows us to alter the degree of revenue variability that is due to a state's particular tax mix. In short, we assume that changes in state-level revenue growth mimic changes in the state's economic activity (i.e., revenue growth has the same transition probabilities as overall economic activity), but permit revenue to be more volatile than overall economic activity. To explore the sensitivity of our estimates, we use three reasonable revenue elasticities (1.2, 1.5, and 1.8) for each state.

Given that P_{LL} is the probability that a contraction in period t–1 will be followed by a contraction in period t, the probability that a downturn will persist exactly t_L periods is given by

$$P_L(t_L) = P_{LL}^{t_L - 1} - P_{LL}^{t_L}.$$

Therefore, if one computes (i) each state's revenue shortfall for a contraction lasting $t_L = 1, 2, \ldots, \infty$ periods and (ii) the probability that a recession of exactly that length will occur, the values may then be used to form a cumulative probability distribution. The distributions may then be used to determine how much states need to save to achieve a given level of certainty. In addition, for a given level of savings, the distributions can also be used to estimate the probability that this level of savings will be sufficient in a future downturn.

To calculate the shortfalls, we set revenue growth at a monthly rate of g_H during each expansion period and at a rate of g_L during each contraction period. Shortfalls are measured relative to an amplitude parameter, γ, that is nothing more than the target monthly growth rate in revenue during each recession period. Although γ may take on any value, we calculate shortfalls using both $\gamma = 0$ and $\gamma = g_H$. Setting $\gamma = g_H$ measures the shortfall relative to the average expansion growth rate in revenue, whereas setting $\gamma = 0$ measures the shortfall relative to zero revenue growth. In other words, $\gamma = g_H$ will generate the level of savings required to maintain the average expansion growth rate in revenue throughout a downturn, while $\gamma = 0$ yields the level of savings needed to sustain a constant level of revenue (or zero growth rate) throughout a slowdown.

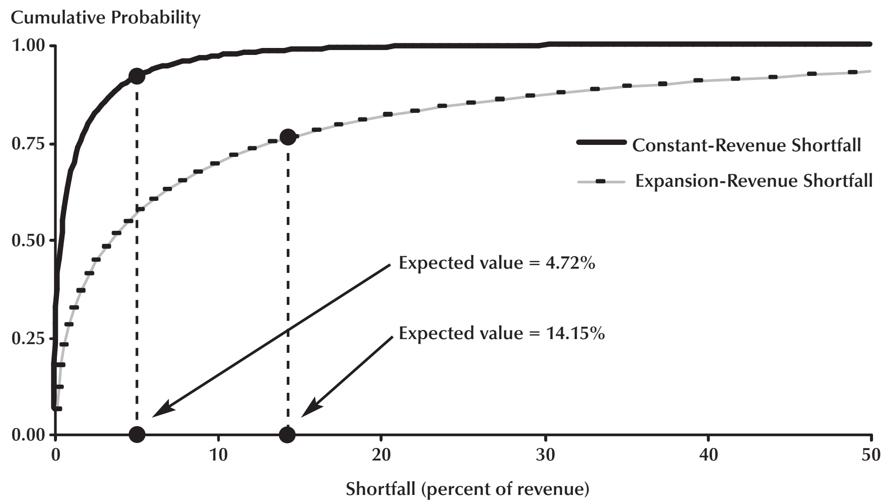
If an expansion lasts t_H periods, then the state's level of revenue will be equal to $R_0(1 + g_H)^{t_H}$, where g_H is the (per-period) expansion growth rate in revenue and R_0 is the initial level of revenue. Assuming a contraction begins and the (per-period) growth rate in revenue switches to g_L, the level of revenue will then be equal to $R_0(1 + g_H)^{t_H}(1 + g_L)$ after the first low-growth period and the total revenue shortfall will be equal to $R_0(1 + g_H)^{t_H}[(1 + \gamma) - (1 + g_L)]$. Relative to revenue in the previous expansion period, which effectively measures the shortfall as a percentage of revenue, the shortfall may be written as $(1 + \gamma) - (1 + g_L)$. Hence, for a recession lasting t_L periods, the total revenue shortfall expressed as a share of revenue will be

$$\varsigma(t_L) = \sum_{i=1}^{t_L}(1+\gamma)^i - \sum_{i=1}^{t_L}(1+g_L)^i. \tag{3}$$

For each state in the Eighth District, we assume that a recession may persist for a maximum of 30 years and construct shortfall distributions using

Figure 1

Cumulative Density Functions of Revenue Shortfalls (Elasticity = 1.2, g_H = 0.351, g_L = –0.194, P_{HH} = 0.980, and P_{LL} = 0.937)



both $\gamma = 0$ and $\gamma = g_H$, which we refer to as a "constant-revenue shortfall" and "expansion-revenue shortfall," respectively. Figure 1 illustrates sample cumulative density functions for both shortfalls using the median parameter estimates in Table 2 and a revenue elasticity of 1.2.

The expected value of the constant-revenue shortfall is 4.72 percent of revenue, whereas the mean of the expansion-revenue shortfall is 14.15 percent. The expected shortfall values are reported for each District state in Table 3 using revenue elasticities of 1.2, 1.5, and 1.8.[8]

Depending on the revenue elasticity, the median state in the Eighth District can expect to encounter a constant-revenue shortfall of between 4.6 and 6.8 percent of revenue during a given recession. Because the magnitude of a constant-revenue shortfall is a function of both the state's average recession growth and the expected duration of a recession, the expected constant-revenue shortfall in Illinois is much larger than the shortfall for any other state in the Eighth District. In contrast, the moderate recession growth rates in Arkansas, Mississippi, and Tennessee imply that these states could maintain a constant level of revenue during a typical downturn with reserve balances of approximately 3 percent of the budget.

The expansion-revenue shortfall estimates, which depend on the duration of a recession plus the difference between the average expansion and average recession growth rates, are noticeably larger than this 3 percent for every state in the District. In fact, the expansion-revenue shortfalls exceed 10 percent of the state's revenue for every elasticity value in five of the District's seven states and exceed this threshold in all seven states if the elasticity is 1.5 or larger. With an elasticity of 1.5, for example, the typical state in the Eighth District can expect a budget shortfall between 15 and 17 percent of revenue during a "normal" downturn, but the estimates range from a high of nearly 32 percent in Illinois to a low of just over 11 percent in Indiana and Mississippi.

Although the expansion-revenue shortfall estimates are quite large, it is important to recall

[8] The shortfall distributions were constructed by varying the number of periods (length of recessions) and restricting revenue to grow at its estimated average rate each period, g_L. Wagner and Elder (2006) explored an alternative approach by varying both the length of recessions and per-period growth rate in revenue. They find that both approaches produced similar results.

Table 3

Expected Revenue Shortfalls for Eighth District States (percentage of revenue)

	Constant-revenue shortfall ($\gamma = 0$)			Expansion-revenue shortfall ($\gamma = g_H$)		
	Revenue elasticity			Revenue elasticity		
	1.2	1.5	1.8	1.2	1.5	1.8
Arkansas	2.26	2.81	3.36	12.24	15.50	18.86
Illinois	9.14	11.28	13.37	25.09	31.68	38.43
Indiana	4.64	5.74	6.81	9.07	11.33	13.60
Kentucky	4.64	5.75	6.84	13.89	17.51	21.19
Mississippi	1.56	1.95	2.33	9.12	11.54	14.02
Missouri	6.08	7.52	8.94	17.50	22.08	26.76
Tennessee	1.43	1.78	2.13	11.86	15.07	18.38
Mean	4.25	5.26	6.25	14.11	17.82	21.61
Median	4.64	5.74	6.81	12.24	15.50	18.86
Maximum	9.14	11.28	13.37	25.09	31.68	38.43
Minimum	1.43	1.78	2.13	9.07	11.33	13.60

Table 4

Projected Fiscal Standing of Eighth District States

	Projected FY 2007-end balance (share of revenue)	Probability FY 2007 balance is sufficient	
		Constant-revenue shortfall	Expansion-revenue shortfall
Arkansas	5.33	0.853	0.552
Illinois	3.34	0.512	0.336
Indiana	6.10	0.756	0.645
Kentucky	7.85	0.808	0.603
Mississippi	4.62	0.894	0.581
Missouri	8.55	0.767	0.573
Tennessee	4.77	0.958	0.652
Mean	5.79	0.793	0.563
Median	5.33	0.808	0.581
Maximum	8.55	0.958	0.652
Minimum	3.34	0.512	0.336

NOTE: FY is fiscal year. Projected FY 2007 balances were obtained from individual state budgets.

that measuring shortfalls relative to expansions provides a useful upper bound for analyzing state fiscal stress. If policymakers were to save according to their state's expansion-revenue shortfalls, then, on average, the state would be able to avoid *all* expenditure reductions and tax increases for the duration of a slowdown.

An alternative perspective is to use each state's shortfall distributions to determine the probability that the state's current level of savings is sufficient to offset a given shortfall. We do this for each state using the state's fiscal-year-end projections for 2007. The results are provided below in Table 4.

We looked at Eighth District states' fiscal year 2007 projections and found that the average state will have reserve balances in excess of 5 percent. Moreover, the probability that any state's savings is sufficient to fully offset a downturn is, for the most part, quite high. For example, our estimates indicate that the probability is roughly 0.80 that District states will be able to maintain a constant level of revenue for the duration of a recession without relying on tax increases or spending reductions. The estimates range from a high of over 95 percent in Tennessee to a low of just over 50 percent in Illinois. In terms of hedging an expansion-revenue shortfall, we find that there is nearly a 60 percent chance that District states will be able to continue the average expansion growth rate in revenue during a slowdown without the use of other fiscal adjustments. In fact, all of the District states except Illinois have at least a 55 percent chance of escaping major fiscal adjustments relative to baseline conditions should a slowdown begin in 2007.

Probability Distributions of State Savings Rates

Because the parameters from the Markov-switching regressions describe the distribution of both expansions and contractions, Wagner and Elder (2006) estimate savings rates that are based on all of the possible expansion-contraction combinations that may occur in a given state. In this section of the paper we show how these savings rates are obtained, which essentially provide a benchmark for policymakers interested in insuring against fiscal shocks.

Assuming that policymakers save a fraction of revenue (s) during each period of an expansion, revenue will be equal to $R_0(1 + g_H)$ and savings will be $R_0 s\,(1 + g_H)$ and at the end of one period. Following t_H periods of expansion, the state's accumulated savings, compounding at a rate r, will be given by

$$R_0 s \sum_{j=1}^{t_H} (1+r)^{t_H - j+1} (1+g_H)^j. \tag{4}$$

If revenue growth switches from an expansion to a contraction, then the revenue shortfall in the first low-growth period will be the difference between actual revenue, $R_0(1 + g_H)^{t_H}(1 + g_L)$, and the target level of revenue, $R_0(1 + g_H)^{t_H}(1 + \gamma)(1 - s)$, where γ denotes the amplitude parameter specifying the target revenue growth rate during contractions.

Prohibiting states from saving during contraction periods, the revenue shortfall in just the first contraction period will be equal to

$$R_0\left[(1+g_H)^{t_H}(1+\gamma)(1-s)-(1+g_H)^{t_H}(1+g_L)\right].$$

For a recession lasting t_L periods, the state's cumulative revenue shortfall may be written as

$$R_0(1+g_H)^{t_H}\left[(1-s)\sum_{i=1}^{t_L}(1+\gamma)^i - \sum_{i=1}^{t_L}(1+g_L)^i\right]. \tag{5}$$

Because equation (5) is the state's revenue shortfall from a downturn lasting t_L periods and equation (4) is the state's savings from an expansion lasting t_H periods, setting equations (4) and (5) equal to one another and solving for s yields the faction of current revenue the state must save during each of the t_H expansion periods to accumulate savings equal to the revenue shortfall. This savings rate is given by

$$s(t_H,t_L) = \frac{(1+g_H)^{t_H}\left[\sum_{i=1}^{t_L}\left[(1+\gamma)^i-(1+g_L)^i\right]\right]}{\sum_{j=1}^{t_H}(1+r)^{t_H-j+1}(1+g_H)^j + (1+g_H)^{t_H}\sum_{i=1}^{t_L}(1+\gamma)^i}. \tag{6}$$

The savings rate given by equation (6) applies to a specific expansion length and a specific con-

Table 5

Expected Savings Rates for Eighth District States (percentage of revenue)

	Constant-revenue shortfall ($\gamma = 0$)			Expansion-revenue shortfall ($\gamma = g_H$)		
	Revenue elasticity			Revenue elasticity		
	1.2	1.5	1.8	1.2	1.5	1.8
Arkansas	0.39	0.49	0.59	2.12	2.71	3.33
Illinois	1.52	1.89	2.27	4.28	5.51	6.80
Indiana	1.03	1.29	1.55	2.08	2.65	3.23
Kentucky	0.86	1.08	1.30	2.61	3.35	4.11
Mississippi	0.33	0.41	0.50	1.92	2.45	3.00
Missouri	1.08	1.35	1.63	3.17	4.07	5.01
Tennessee	0.27	0.34	0.41	2.22	2.84	3.49
Mean	0.78	0.98	1.18	2.63	3.37	4.14
Median	0.86	1.08	1.30	2.22	2.84	3.49
Maximum	1.52	1.89	2.27	4.28	5.51	6.80
Minimum	0.27	0.34	0.41	1.92	2.45	3.00

traction length. If we assume that the length of expansions (t_H) and the length of recessions (t_L) are independent, then the probability that an expansion persisting t_H periods will be followed by a recession lasting t_L periods can be computed as $P_H(t_H) \times P_L(t_L)$, where

$$P_j\left(t_j\right) = P_{jj}^{t_j - 1} - P_{jj}^{t_j} \text{ for } j = H, L.$$

Assuming that both expansions and recessions last for a maximum of 30 years (or 360 months), we form savings rate distributions from the 129,600 possible expansion-contraction combinations. The expected savings rate for constant-revenue shortfalls ($\gamma = 0$) and expansion-revenue shortfalls ($\gamma = g_H$) are presented in Table 5 using revenue elasticities of 1.2, 1.5, and 1.8.

The savings rates show the fraction of total revenue that a state must save during each expansion period in order to accumulate sufficient savings to offset a "normal" fiscal cycle. Assuming a revenue elasticity of 1.5 for instance, if the median state in the Eighth District saved 1.08 percent of revenue each expansion period, then the state would be able to maintain a constant level of revenue during a typical downturn and would have zero reserve balances when the downturn ends. If the objective is to maintain the average expansion rate of revenue growth throughout a recession, then the median state would need savings equal to 2.84 percent during each expansion period.[9] For a given target growth rate in revenue (γ), the closer policymakers are to achieving the state's expected savings rate, the more likely it is that the state will be able to avoid expenditure reductions and tax increases in the next recession.

CONCLUSION

Slowdowns in economic activity place tremendous strain on state budgets and frequently force policymakers to enact sizable spending cuts and tax increases to close budget shortfalls. Following Wagner and Elder (2006), this paper uses a basic Markov-switching regression model to form empirical distributions of the monthly revenue cycles in

[9] The Markov-switching model assumes that the underlying regime is not observable. However, a reasonable approach to implementing a savings rule in practice would be to rely on the estimated probability that a state is in an expansion at a given point in time, $P(S_t = 1)$. The simplest possible rule for the state to follow would be to assume that the economy is expanding (and therefore save) if $P(S_t = 1) > 0.5$ and save nothing otherwise.

Eighth District states. We then estimate the revenue shortfalls that District states are likely to experience in a future recession using multiple fiscal objectives.

We find, for instance, that the typical state in the District needs reserve balances equal to 4 to 6 percent of revenue to maintain a constant level of revenue during the next recession without relying on spending cuts and tax increases. If the goal is to preserve the average expansion growth rate in revenue during a slowdown, while simultaneously avoiding spending or tax adjustments, then the average state would need to have savings equal to 15 to 17 percent of revenue before the start of the next recession. Based on fiscal-year-end projections for 2007, we find that all of the Eighth District states except Illinois have a greater than 50 percent chance of avoiding major fiscal adjustments should a slowdown begin in 2007.

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