Simple Rules for Determining How States Can Save for a Rainy Day

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Various articles have been written concerning the level of savings states should accumulate to weather an economic downturn, and since states have differing business cycle characteristics a one-size-fits-all approach does not seem to make much sense. Once the level of accumulated savings is determined, the next question concerns the savings rate that will enable the state to achieve its desired accumulated savings. This article builds on the work of Wagner and Elder (2007) and presents a simplified approach to determine the appropriate savings rate based on each state's risk preferences.

Keywords: fiscal stress, rainy day fund, business cycles, regime-switching

INTRODUCTION

Most states have established a rainy-day fund (RDF) (also referred to as a budget stabilization fund) to help mitigate the almost inevitable decline in government revenue during an economic slowdown. The primary question for state legislators is how much savings their government should attempt to accumulate in their RDF. This issue is addressed by Wagner and Elder (2007). Their analysis is based on the idea that business cycle characteristics vary by state; they use a Markov switching regression framework to estimate the state-specific business cycle parameters. The business cycle characteristics that vary across states include the average growth rates during an economic expansion and contraction and the probabilities describing the likelihood of transitioning from an economic expansion to an economic contraction (and vice versa). Because the revenue each state government collects is affected by the level of economic activity in that state (with revenue increasing during economic expansions and decreasing during economic contractions) the cyclical characteristics of state government revenue collections also varies across states. Since business cycles differ across states in terms of severity and duration, the traditional "one size fits all" approach does not make sense as a guide to how much states should attempt to accumulate.

Wagner and Elder (2007) use these estimates to construct a budget-shortfall probability distribution. This distribution relates the size of a budget shortfall that would occur if a contraction lasts 1, 2, …, T periods with the associated probability of a contraction lasting that number of periods. The probability a contraction lasts a given number of periods is based on the transition probabilities mentioned above and the size of the resulting budget shortfall depends on the average contraction growth rate for that specific state. Once the budget-shortfall probability distribution is established, states can choose a goal for the amount of savings they would like to accumulate based on the risk preferences of each state legislature. In subsequent research using this approach, Elder (2016) updated the parameter estimates of the state-specific business cycle parameters, and in combination with data concerning how much each state has already accumulated in the RDF, determines how prepared states are for a recession by comparing the amount of savings each state had already accumulated in their RDF with their state-specific budget shortfall distribution. Not surprisingly, the budget-shortfall probability distributions and the amount states have accumulated in their RDF display substantial variation. Getting away from a one size fits all approach, and describing the distribution of potential budget shortfalls for each state was an important step to assist policymakers in making more effective decisions concerning how much savings to accumulate in their RDF.

Although having state-specific budget-shortfall probability distributions is an integral piece of information that policymakers can use to assist them in determining how much to accumulate in their RDF, understanding exactly how to achieve the desired accumulated savings goals is also important. In other words, knowing the amount of savings to accumulate is important, but knowing what savings rate is necessary to achieve these accumulated amounts is also important. Wagner and Elder (2007) describe a methodology that involves all of the parameter estimates from the Markov switching regression. Still, this methodology was rather complex, and that complexity likely reduces the usefulness for policymakers. This essay uses the parameter estimates developed in Elder (2016) and describes a simpler algorithm to assist legislators in determining the sate-specific savings rates required to achieve specific accumulated savings amounts.

The following sections contain a discussion of the Markov switching regression, how the parameter estimates are used to calculate a budget-shortfall probability distribution, a discussion concerning the formation of the expansion-duration probability distribution, a discussion of the empirical results, and concluding remarks.

METHODOLOGY AND DATA

The main contribution of this paper is to discuss the methodology to determine the savings rates states can follow to achieve a desired level of accumulated savings. The savings rates are a function of the updated Markov switching regression parameter estimates in Elder (2016); therefore, this section provides only a brief overview of the Markov switching regression and data used to estimate the parameters of interest.[1]

As mentioned above, Wagner and Elder (2007) use a Markov switching regression to estimate the parameters that describe each state's business cycle characteristics, and Elder (2016) provides an update of those parameter estimates. The Markov switching regression is a useful regression tool when the data generating process of a series is thought to be driven by two distinct regimes; the series is in a high-growth regime in some periods and in a low-growth regime the other periods. When the series is in a high-growth regime, the series grows at rate μH, and when the series is in a low-growth regime the series grows at rate μL. Furthermore, suppose the series is in a high-growth regime in period t. In that case, there is a probability PHH that the series will continue to be in a high-growth regime in period t+1 (and the probability of transitioning from a high-growth regime to a low-growth regime is 1-P¬HH). Likewise, if the series is in a low-growth regime in period t there is a probability PLL that the series will remain in a low-growth regime in period t+1. The Markov switching regression is not applied directly to a state-government revenue series because policy changes may affect the levels or growth rates of government revenue. Instead, the Markov switching regression is applied to the monthly state coincident index (1979:09–2015:12) (described by Crone and Clayton-Matthews (2005) and published monthly by the Philadelphia Federal Reserve). An additional parameter is used to extend the analysis to describe the cyclical characteristics of state government revenue collections; the growth rate of government revenue during high-growth or low-growth regimes is thereby given by gH (= φ*μH) and gL (= φ*μL) where φ is the elasticity of government revenue to changes in the economic activity for a specific state (estimates are from Kodrzycki (2015)).

Once the growth rates and transition probabilities are estimated from the Markov switching regression, they are used to construct the budget-shortfall probability distributions. Specifically, the low-growth regime growth rate (gL) for each state is used to estimate the size of budget shortfalls occurring during economic contractions lasting various durations, while the transition probability parameter, PLL, is used to calculate the probabilities that a contraction will persist for a given number of periods. The probability that a contraction lasts exactly k periods is calculated as P_LL^(k-1)-P_LL^k. Therefore, if a state has a low-growth regime growth rate of gL = -1.0% and transition probability PLL = 0.80 then the probability a shortfall lasts exactly one period is 0.20, the probability a contraction lasts for exactly two periods is 0.16 and so on. If a contraction lasts for one period, then the shortfall is 1.0% (of pre-contraction monthly revenue or 0.083% of pre-contraction annual revenue), if the contraction lasts for two periods, then the shortfall in just the second period is 1.99% (of pre-contraction monthly revenue) and the cumulative shortfall is 2.99% (relative to pre-contraction monthly revenue or 0.249% of pre-contraction annual revenue). The table below shows the calculations for a contraction lasting one to 14 periods.

TABLE 1
PERIOD AND CUMULATIVE BUDGET SHORTFALL PROBABILITY DISTRIBUTION

# of Months	Probability	Cumulative Probability	Shortfall	Cumulative Shortfall (% of monthly revenue)	Cumulative Shortfall (% of annual revenue)
1	0.200	0.200	1.000	1.000	0.083
2	0.160	0.360	1.990	2.990	0.249
3	0.128	0.488	2.970	5.960	0.497
4	0.102	0.590	3.940	9.900	0.825
5	0.082	0.672	4.901	14.801	1.233
6	0.066	0.738	5.852	20.653	1.721
7	0.052	0.790	6.793	27.447	2.287
8	0.042	0.832	7.726	35.172	2.931
9	0.034	0.866	8.648	43.821	3.652
10	0.027	0.893	9.562	53.383	4.449
11	0.021	0.914	10.466	63.849	5.321
12	0.017	0.931	11.362	75.210	6.268
13	0.014	0.945	12.248	87.458	7.288
14	0.011	0.956	13.125	100.584	8.382

Based on this example, there is a 79.0% chance a contraction will last 7 or fewer months (and a 73.8% chance a contraction will last 6 or fewer months). Therefore, if a state wanted to be at least 75% sure they had accumulated a sufficient amount in their RDF then their objective should be to accumulate an amount equivalent to 2.287% of their annual revenue. Alternatively, if they wanted to be at least 90% sure they have sufficient savings, they should accumulate an amount equivalent to 5.321% of their annual revenue (because there is a 91.4% chance a contraction will last 11 or few months). Based on the complete distribution, the expected cumulative shortfall is 2.0% (this is similar to the 75th percentile cumulative shortfall because of the skewness of the distribution) so if a state just wants to accumulate sufficient savings to weather an average contraction, then this is the amount they would need to accumulate in their RDF. Once policymakers use a budget shortfall probability distribution similar to the above distribution (but one constructed from their state-specific parameter estimates), they need to decide how to accumulate this desired amount of savings. To determine this savings *rate*, they need to have some idea of how long they have to accumulate their target level of savings. In other words, they need to know the probability distribution that describes how long their expansion regime will/may last.

Similar to the construction of the above distribution, an expansion-duration distribution can be constructed depicting the number of expansion periods along with the associated probabilities. The probability an expansion last exactly k periods is $P_{HH}^{k-1} - P_{HH}^{k}$. Therefore, if $P_{HH} = 0.90$, then there 10% chance an expansion will last exactly 1 period, a 9% chance an expansion will last exactly 2 periods (or a 19% chance an expansion will last at least 2 periods), and so on. The table below depicts the expansion-duration probability distribution if P_{HH} =0.90.

TABLE 2
EXPANSION DURATION PROBABILITY DISTRIBUTION

# of Months	Probability	Cumulative Probability
1	0.100	0.100
2	0.090	0.190
3	0.081	0.271
4	0.073	0.344
5	0.066	0.410
6	0.059	0.469
7	0.053	0.522
8	0.048	0.570
9	0.043	0.613
10	0.039	0.651
11	0.035	0.686
12	0.031	0.718
13	0.028	0.746
14	0.025	0.771
15	0.023	0.794
16	0.021	0.815
17	0.019	0.833
18	0.017	0.850
19	0.015	0.865
20	0.014	0.878
21	0.012	0.891
22	0.011	0.902

Based on this distribution, if a state wants to be 75% sure to accumulate their target amount of savings while their economy is expanding, then they would want to accumulate their target amount of savings in 14 months. Alternatively, if they wanted to be 90% sure to accumulate their target amount of savings, they should accumulate their target level of savings in 22 months. Finally, the expected duration of an expansion is 10 months.[2]

EMPIRICAL RESULTS

The table below shows various points on each state's budget-shortfall probability distribution (along with the expected value) and various points along the expansion duration probability distribution (along with the expected value). The Markov switching regression parameter estimates and elasticities for each state are shown in the Appendix.

TABLE 1
REVENUE SHORTFALL DISTRIBUTIONS OF STATE REVENUE CONTRACTIONS
(% OF ANNUAL REVENUE)

	Shortfall Distributions				Expansion Duration Distributions			
State	**Expected**	**50%**	**75%**	**90%**	**Expected**	**50%**	**75%**	**90%**
Alabama	9.3	2.7	9.4	25.0	71.4	50.0	21.0	8.0
Alaska	31.0	12.6	38.0	84.0	194.4	139.0	58.0	22.0
Arizona	3.9	1.0	3.8	10.0	45.5	32.0	13.0	5.0
Arkansas	2.7	0.8	2.7	7.3	58.8	41.0	17.0	7.0
California	4.0	1.0	3.9	10.8	50.0	35.0	15.0	6.0
Colorado	7.9	2.4	8.3	20.9	62.5	43.0	18.0	7.0
Connecticut	8.4	2.4	8.4	21.8	62.5	43.0	18.0	7.0
Delaware	3.8	0.9	3.6	10.0	52.6	37.0	15.0	6.0
Florida	6.7	1.8	6.5	17.7	90.9	63.0	27.0	10.0
Georgia	7.1	2.0	6.9	18.4	55.6	39.0	16.0	6.0
Hawaii	13.5	3.5	13.6	34.8	47.6	33.0	14.0	5.0
Idaho	12.0	3.7	12.2	31.1	71.4	50.0	21.0	8.0
Illinois	16.4	4.7	16.6	43.5	76.9	53.0	22.0	9.0
Indiana	5.4	1.7	5.4	14.5	71.4	50.0	21.0	8.0
Iowa	4.7	1.5	4.9	12.1	83.3	58.0	24.0	9.0
Kansas	5.6	1.6	6.0	15.0	83.3	58.0	24.0	9.0
Kentucky	7.0	2.1	7.0	18.6	66.7	46.0	20.0	7.0
Louisiana	16.1	5.2	17.1	43.0	71.4	50.0	21.0	8.0
Maine	6.4	1.6	6.5	17.5	37.0	26.0	11.0	4.0
Maryland	9.4	3.0	10.2	24.4	71.4	50.0	21.0	8.0
Massachusetts	10.4	2.9	10.2	27.8	66.7	46.0	20.0	7.0
Michigan	13.3	4.6	14.5	34.8	52.6	37.0	15.0	6.0
Minnesota	5.0	1.3	5.1	12.9	83.3	58.0	24.0	9.0
Mississippi	5.8	1.5	5.7	15.3	37.0	26.0	11.0	4.0
Missouri	10.5	3.0	10.9	28.6	71.4	50.0	21.0	8.0
Montana	21.1	7.1	23.5	57.6	55.6	39.0	16.0	6.0
Nebraska	4.3	1.2	4.2	11.6	71.4	50.0	21.0	8.0
Nevada	13.3	3.9	14.4	35.1	66.7	46.0	20.0	7.0
New Hampshire	2.2	0.6	2.3	5.7	58.8	41.0	17.0	7.0
New Jersey	5.7	1.5	5.8	15.4	47.6	33.0	14.0	5.0
New Mexico	4.9	1.4	4.9	12.8	62.5	43.0	18.0	7.0
New York	5.8	1.5	5.7	15.4	62.5	43.0	18.0	7.0
North Carolina	6.1	1.8	6.3	16.1	62.5	43.0	18.0	7.0
North Dakota	0.0	0.0	0.0	0.0	15.4	11.0	5.0	2.0
Ohio	14.2	4.7	14.6	38.4	76.9	53.0	22.0	9.0
Oklahoma	13.7	3.7	13.6	37.2	71.4	50.0	21.0	8.0
Oregon	15.6	4.8	17.2	42.5	62.5	43.0	18.0	7.0
Pennsylvania	4.7	1.3	4.6	12.0	66.7	46.0	20.0	7.0
Rhode Island	10.3	3.0	10.2	27.1	83.3	58.0	24.0	9.0
South Carolina	8.2	2.2	8.1	21.6	52.6	37.0	15.0	6.0
South Dakota	1.8	0.5	1.9	4.8	62.5	43.0	18.0	7.0
Tennessee	4.9	1.5	4.8	12.8	66.7	46.0	20.0	7.0

Texas	5.8	1.5	5.8	15.3	71.4	50.0	21.0	8.0
Utah	4.2	1.1	4.3	11.2	62.5	43.0	18.0	7.0
Vermont	4.6	1.4	4.6	12.0	50.0	35.0	15.0	6.0
Virginia	6.6	1.8	6.7	17.5	40.0	28.0	12.0	5.0
Washington	2.3	0.6	2.2	5.9	71.4	50.0	21.0	8.0
West Virginia	3.4	1.1	3.6	8.9	71.4	50.0	21.0	8.0
Wisconsin	8.1	2.9	8.8	22.0	76.9	53.0	22.0	9.0
Wyoming	19.5	7.2	22.0	51.5	100.0	69.0	29.0	11.0

In general, states first need to choose their target level of total accumulated savings they are trying to achieve. This target level of savings is based on the first four columns of the above table. They then choose how confident they want to be in terms of accumulating that amount of savings based on the last four columns of the above table. Once these two pieces of information are determined, the savings rate is calculated as *12*target savings/expansion periods.* Again, the target savings can be determined as the 50th, 75th, or 90th percentiles of the budget-shortfall probability distribution or the expected budget shortfall, and the number of expansion periods can be determined as the 50th, 75th, or 90th percentiles of the expansion-duration probability distribution or the expected expansion duration.

For example, if Texas wanted to accumulate savings that would allow them to weather 75% of all possible budget shortfalls, then they would want to accumulate an amount equivalent to 5.8% of their annual revenue. If they also decide that they want to be 75% sure of accumulating this amount of savings before their economy enters a contraction, then they have 21 months to accumulate savings. Therefore, they would need to save 3.31% of their monthly revenue.[3] Suppose alternatively, they wanted to be 90% sure to accumulate the same level of savings before their economy enters a contraction. In that case, they need to accumulate their savings in only 8 months so they would need to save 8.7% of their monthly revenues.

These calculations assume a state is starting with zero in their RDF; alternatively, if a state already has accumulated savings in their RDF equal to X% of their annual revenues then the calculation is modified by simply subtracting X% from their target savings. If a state achieves its target accumulated savings goal in their target number of periods and their economy continues to expand then the state could either cut back on their savings (to a level that would maintain their relative savings position) or continue to save at the same rate and achieve a higher target accumulated savings goal.

CONCLUSION

Historically, states have adhered to a one-size-fits-all approach to how much they should try to accumulate in their RDF. Wagner and Elder (2007) showed that this does not make any sense since the business cycle characteristics differ across states, and they provided a more advanced statistical approach to determining how much states should accumulate based on the likelihood of contractions lasting various numbers of periods, resulting in budget shortfalls of varying amounts. Although this contributed significantly to the RDF literature, their approach to computing savings rates was rather difficult to understand and implement. In this note, a simplified approach to determining the appropriate savings rate to achieve a desired level of savings has been laid out where states can determine their savings rate based on their risk preferences. First, states need to decide how much they want to accumulate in their RDF (based on how severe a contraction they want to be able to weather) and then decide how quickly (or slowly) they want to achieve this level of savings. This simplified algorithm can help state legislators make more informed savings rate decisions.

ENDNOTES

1. For a more detailed description of the estimation of the Markov switching regression algorithm, readers are referred to either Wagner and Elder (2007) or Elder (2016).
2. The expected duration is $(1\text{-}P_{HH})^{-1}$.
3. This calculation is a simplified example that ignores growth while the state is in an expansion. Taking growth into consideration, if the state's target savings amount is denoted X and the number of expansion periods to accumulate that amount is denoted N then the savings rate formula is $X \sum_{j=N-11}^{N}(1+g_H)^j \Big/ \sum_{i=1}^{N}(1+g_H)^i$.

REFERENCES

Crone, T.M., & Clayton-Matthews, A. (2005). Consistent Economic Indexes for the 50 States. *Review of Economics and Statistics*, *87*, 593–603.

Elder, E. (2016). Weathering the Next Recession: How Prepared are US States?. *Journal of Applied Business and Economics*, *18*(7), 32–52.

Kim, C.-J., & Nelson, C.R. (1998). Business Cycle Turning Points, A New Coincident Index, and Tests of Duration Dependence Based on a Dynamic Factor Model with Regime-Switching. *The Review of Economics and Statistics*, *80*(2), 188–201.

Kim, C.-J., & Nelson, C.R. (1999). *State-Space Models with Regime Switching: Classical and Gibbs Sampling Approaches with Applications*. Cambridge: MIT Press.

Kodrzycki, Y.K. (2015). *Smoothing State Tax Revenues Over the Business Cycle: Gauging Fiscal Needs and Opportunities*. Federal Reserve Bank of Boston Working Paper No. 14–11.

Wagner, G.A., & Elder, E.M. (2007). Revenue Cycles and the Distribution of Shortfalls in U.S. States: Implications for an 'Optimal' Rainy-Day Fund. *National Tax Journal*, *60*(4), 727–742.

APPENDIX

TABLE A1
MARKOV SWITCHING PARAMETER ESTIMATES FOR EACH STATE

State	$\hat{\mu}_L$	$\hat{P}_{LL}$	$\hat{P}_{HH}$
Alabama	−0.249	0.935	0.986
Alaska	−1.085	0.907	0.995
Arizona	−0.017	0.975	0.978
Arkansas	−0.075	0.955	0.983
California	−0.059	0.948	0.98
Colorado	−0.195	0.939	0.984
Connecticut	−0.189	0.949	0.984
Delaware	−0.074	0.960	0.981
Florida	−0.399	0.917	0.989
Georgia	−0.153	0.936	0.982
Hawaii	−0.144	0.967	0.979
Idaho	−0.489	0.921	0.986
Illinois	−0.269	0.953	0.987
Indiana	−0.564	0.910	0.986
Iowa	−0.377	0.918	0.988
Kansas	−0.396	0.922	0.988
Kentucky	−0.406	0.910	0.985
Louisiana	−0.637	0.920	0.986
Maine	−0.043	0.982	0.973
Maryland	−0.309	0.926	0.986
Massachusetts	−0.204	0.946	0.985
Michigan	−0.937	0.895	0.981
Minnesota	−0.097	0.950	0.988
Mississippi	−0.226	0.925	0.973
Missouri	−0.202	0.955	0.986
Montana	−0.484	0.927	0.982
Nebraska	−0.177	0.929	0.986
Nevada	−0.556	0.930	0.985
New Hampshire	−0.223	0.923	0.983
New Jersey	−0.130	0.947	0.979
New Mexico	−0.078	0.949	0.984
New York	−0.187	0.925	0.984
North Carolina	−0.211	0.934	0.984
North Dakota	0.134	0.988	0.935
Ohio	−0.768	0.898	0.987
Oklahoma	−0.413	0.933	0.986
Oregon	−0.631	0.902	0.984
Pennsylvania	−0.349	0.904	0.985
Rhode Island	−0.404	0.936	0.988
South Carolina	−0.278	0.925	0.981
South Dakota	−0.174	0.934	0.984
Tennessee	−0.256	0.911	0.985
Texas	−0.225	0.932	0.986
Utah	−0.101	0.942	0.984
Vermont	−0.266	0.928	0.98

Virginia	−0.032	0.969	0.975
Washington	−0.166	0.932	0.986
West Virginia	−0.387	0.907	0.986
Wisconsin	−1.636	0.875	0.987
Wyoming	−1.505	0.895	0.99

The parameters of the model are estimated using the Bayesian Gibbs-sampling approach for Markov switching models developed by Kim and Nelson (1998). I acknowledge the use of the computer routines described in Chang-Kim and Nelson (1999).

TABLE A2
STATES' ELASTICITY OF REVENUE TO ECONOMIC CONDITIONS

State	Elasticity	State	Elasticity
Alabama	2.026	Montana	3.369
Alaska	4.317	Nebraska	1.532
Arizona	1.736	Nevada	1.568
Arkansas	0.891	New Hampshire	0.718
California	2.256	New Jersey	1.542
Colorado	1.909	New Mexico	2.033
Connecticut	1.452	New York	2.205
Delaware	0.992	North Carolina	1.595
Florida	1.483	North Dakota	1.992
Georgia	2.388	Ohio	2.732
Hawaii	1.290	Oklahoma	1.986
Idaho	2.056	Oregon	3.414
Illinois	1.775	Pennsylvania	1.555
Indiana	0.991	Rhode Island	1.358
Iowa	1.051	South Carolina	2.126
Kansas	1.091	South Dakota	0.563
Kentucky	1.793	Tennessee	1.915
Louisiana	2.265	Texas	1.509
Maine	0.588	Utah	1.745
Maryland	2.172	Vermont	1.123
Massachusetts	1.909	Virginia	2.448
Michigan	2.207	Washington	0.771
Minnesota	1.579	West Virginia	0.943
Mississippi	1.818	Wisconsin	1.036
Missouri	1.340	Wyoming	2.195

Source: Yolanda K. Kodrzycki, "Smoothing State Tax Revenues over the Business Cycle: Gauging Fiscal Needs and Opportunities" (Working Paper No. 14-11, Federal Reserve Bank of Boston, 2015)