# Are State Governments Patient Stewards of the Public Purse?

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**PRELIMINARY AND INCOMPLETE**

**Abstract**

This paper examines whether, and the extent to which, state governments are able to smooth their consumption expenditures over time in the face of cyclical fluctuations in own revenue. We explore this possibility by estimating a buffer stock model, where state government political consumption is expenditure plus tax cuts. Data exploration suggests that states maintain significant "other fund" balances irrespective of whether they maintain a rainy day fund, and estimation suggests that these balances are used to smooth government expenditure over the business cycle. Simulation consistent with estimated behavior finds that state governments are surprisingly patient, with a reasonable degree of risk aversion.

# 1 Introduction

Are governments prone to deficit spending or are they rational stewards of the public purse? The answer may depend on history and institutions, as witnessed by the difference between say, Germany and Argentina, where the former runs government surpluses and the latter is a serial defaulter. An increasing number of countries, however, feel the need to constrain their governments as witnessed by the large and increasing number of balanced budget rules, see IMF (xxx), indicating an emerging consensus that constraints are needed. The disadvantage of balanced budget rules, however, is the apparent loss in ability to smooth expenditures in the face of economic cyclicality.

In this paper, we examine the extent to which US states are able to smooth expenditures over the business cycle despite the pervasive balanced budget constraints. Specifically, we show that the buffer stock model of consumption, where the government "consumes" public expenditure, fits U.S. state governments reasonably well. Further, we find that the success of states in smoothing their expenditures does not particularly rely on the relatively new "rainy day fund" saving accounts, but that instead states have developed alternative institutional mechanisms that allow inter-temporal smoothing. We estimate a buffer stock model using state finance data by simulated GMM and find that U.S. state governments behave as consumers who are risk averse but surprisingly patient, providing a potential rationale for more flexible budgetary rules.

Consumption smoothing is, on the surface, a difficult task for state governments with balanced budget rules.[1] While these rules are broadly viewed as constraints on borrowing for current expenditure, they could also be viewed as limits to saving.[2] A second problem is the presumed impatience of government officials. That is, to the extent politicians are more impatient than residents, the politicians will desire to spend all savings resources during their term, irrespective of potential future demands on those resources.

Models which describe political impatience include Phelan and Amador (2017) where political parties optimize with the knowledge that they may be replaced. Alternatives include Jackson and Yariv (2014) where aggregation of preferences leads to present-bias. An alternative, however, is recent work by Craig et al. (2016) which suggests that at least in certain institutional settings, government officials may act more patient than residents. Further, the recent push to implement and expand rainy day funds suggests that some voters, at least, are willing to believe that politicians may be able to solve intertemporal problems with appropriate savings mechanisms.

We therefore estimate a buffer stock model using general expenditures by state governments. To do so requires an examination of state government data on current resources. While many states have "rainy day funds," (RDFs) to which contributions are mandatory and which can be tapped in bad economic times, we find that at least currently these funds are too small to provide substantial smoothing ability. Instead, however, we find, using data on "free other funds," that state governments have generated resources for smoothing for a

[1] All states except Vermont have such rules, although effectively covering various degrees of total budget authority (Poterba (1994)).

[2] In a mobile society, savings causes efficiency loses to the extent certain people pay into saving but are not resident to benefit from the use of saving.

long period of time.[3] These "other funds" provide sufficient savings for all but the Great Recession of 2008 based on calculations of consumer buffer-stock saving following Carroll (1992) and Carroll (1997).

The 50 U.S. states provides an excellent "laboratory" for our purpose as the states are much more homogeneous than groups of countries, do not have independent monetary policies, and face roughly the same self-imposed constraints (although we will test if the state differences in balanced-budget constraints matter). We explore the data on potential savings using the cash and securities holding of US states. These funds have three general uses, trust fund accounts (pensions and unemployment insurance), funds associated with formal borrowing (generally used on the capital side), and other funds. Our analysis shows other funds are quite large relative to rainy day funds, and amount to almost 80% of annual expenditure. Using this third category as our measure of buffer stock savings, we estimate the buffer stock model using the panel of fifty US states from 1975-2010 using the statistics suggested by Jappelli, Padula and Pistaferri (2008). We then estimate the behavioral parameters matching the moments of the JPP test statistic and average cash-on-hand using simulated method of moments. We find the consumer model fits state governments reasonably well. Our estimates of the discount factor and risk aversion coefficient are 0.949 and 3.027, respectively, using two year budgeting as the individual observations.

The rest of the paper is organized as follows. Section 2 describes the data and the patterns of government income and expenditure. Section 3 presents the Buffer Stock model and the

[3]We cannot definitively say for sure whether these funds are free but these are the only ones we cannot say for sure are ear marked.

mapping of variables from the model to the data. Section 4 describes the empirical test of the model and discusses the results. Section 5 describes the estimation of the behavioral parameters of the model and discusses that we find governments act surprisingly patient and with reasonable risk aversion. Section 6 concludes.

## 2 Data

For our analysis, we construct a panel of 50 U.S. states from 1975 to 2010. Data on State Government finances is obtained from the U.S. Census Bureau's Annual Survey of State and Local Government Finances. A first glance at the state balances (see Figure 1) shows us that states on average keep a positive surplus, These surpluses could be used to smooth expenditures in the face of fluctuations in revenue. There are multiple funds where states could be saving these surpluses. Cash and security holdings seems to come close to the savings category of the state governments. We focus on, however, only the fungible cash component of it (other funds) which can actually be used for financial contingencies.[4] Looking at the evolution of the other funds from 1975 to 2010 and how they fluctuate during recession periods, (see Figure 2), we find that other funds provide some buffer during economic downturns and hence could be a good candidate to smooth expenditures.

[4]One issue to which we expect to return later is the treatment of capital gains. Capital gains are reported in the data for trust funds- primarily pensions- but also for non-trust fund assets. In this first iteration, we have included capital gains as government revenue. This is most likely the correct procedure, as capital gains (losses) can be fungible with other revenue as reflected in contributions. That is, if the pension fund grows faster than expected, it is not unlikely state governments would reduce their own contribution to the pension fund. Similarly, states will be pressured to make at least their full contribution when capital gains are lower than expected. On the other hand, future work on our project will test the sensitivity of our results to the fungibility of this revenue source.

The same can be seen in the growth figures (see Figure 3) where we find that during recessionary periods other funds are used by state governments to smooth their expenditure, as evidenced in its negative growth rate along the gray bars (recession period based on NBER definition). Looking at other sources which state governments could use to smooth consumption, we do not find very robust potential smoothing channels. Among the possibilities we investigate are intergovernmental revenue, debt outstanding and rainy day funds (see Figure 4). Intergovernmental revenue are transfers from the federal government and could provide some smoothing for the state level expenditures. They have been counter-cyclical (implying smoothing) during three of the four recessions, but may not be a sure smoothing mechanism. The primary reason federal grants fluctuate is likely to be specific programs, rather than initiatives to provide fiscal relief to states. Debt on the other hand is very cyclical, and appears to provide almost no smoothing to the states. One reason may be because most states only permit debt for capital, rather than current expenditures. Rainy day funds appear to provide some relief to cyclical fluctuations, but generally are very small relative to the amount needed to provide overall smoothing for state government consumption. Figure 5 shows the size difference between rainy day funds and cash for other purposes, and the size difference is seen to be exponential.

Another way to look at whether states are smoothing their expenditure is to look at the standard deviation of expenditure and revenue (Table 1). We find that standard deviation (both cross sectional and time series) of expenditure is smaller than that of revenues implying that there are smoothing mechanisms which states are using to absorb some of the revenue fluctuations. The data in the table further support that intergovernmental revenue does not serve to smooth state government consumption, as we see that the standard deviation for own revenue is smaller than that for total revenue. Since the difference in the two measures is interegovernmental receipts, this implies that intergovernmental transfers are actually increasing the variance than reducing it (as own revenue is total revenue net of intergovernmental transfers). For other funds we see that the time series standard deviations are much smaller than cross sectional standard deviations, implying that states succeed to at least some extent in smoothing their consumption.

Based on these observations we hypothesize that states may be smoothing their consumption (current expenditure) through cash which is held as other funds. We model the savings behavior of the state government in the following section.

# 3 Model

What can characterize the savings behavior of state governments? Previous studies such as Craig et al. (2016) have shown that for some types of funds, states exhibit behavior similar to that of a buffer stock consumer in that they are sufficiently risk averse and impatient and that there is a target level of wealth (relative to permanent income) that they aim to achieve. We believe that such behavior applies to how they manage their overall finances. In this section, we describe the Buffer Stock Model as formulated by Carroll (1992).[5]

[5]The alternative specification of the buffer stock model is that of Deaton (1991). In his model, there are only permanent shocks and that consumers cannot borrow. Carroll's model generalizes the income process in Deaton to allow for permanent and transitory shocks to income while also removing the borrowing constraint. Furthermore, Carroll allows for a small probability that income goes to zero which, in addition to requiring positive consumption, guarantees that households never borrow. (Carroll (1997), Zeldes (1989), Schechtman

## 3.1 The Buffer Stock Model

The economy is populated by infinitely lived states who maximize the present discounted value of utility derived from consumption.[6] The objective of the state is to maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\rho}}{1-\rho} \tag{1}$$

where $\beta$ is the time discount factor, $C_t > 0$ is consumption and $\rho > 0$ is the coefficient of relative risk aversion. The dynamic budget constraint is

$$W_{t+1} = (1+r)(W_t + Y_t - C_t) \tag{2}$$

where $W_t$ is financial wealth, $r$ is the interest rate and $Y_t$ is income. Following Carroll (1992), we define cash-on-hand as the beginning of period savings plus current period income, $COH_t = W_t + Y_t$.

Income is modeled as the product of a random walk permanent component and i.i.d. transitory component:

$$Y_t = P_t \epsilon_t \tag{3}$$

$$P_t = G P_{t-1} \psi_t \tag{4}$$

where $P_t$ is the permanent component of income, $G$ is the deterministic growth rate of

(1976)).

[6] Because we are concerned with state governments and not politicians, we assume that state governments cannot die and we are agnostic towards changes in political ideology or regime.

income, $\epsilon_t$ is the transitory shock to income and $\psi_t$ is the shock to permanent income. The distribution of the permanent and transitory shocks to income are

$$log(\psi_t) \sim N(-0.5\sigma_\psi^2, \sigma_\psi^2)$$

$$\epsilon_t = \begin{cases} 0 & \text{with probability } \omega \\ \theta/(1-\omega) & \text{with probability } 1-\omega, \text{ where } log(\theta_t) \sim N(-0.5\sigma_\theta^2, \sigma_\theta^2) \end{cases}$$

In our analysis and discussions, we normalize the variables by permanent income.[7] Normalized variables are in lower case: $c_t = C_t/P_t$, $coh_t = (W_t + Y_t)/P_t$ and $y_t = Y_t/P_t$. We do not explicitly model liquidity constraints but Carroll (1997) points out that consumers never borrow due to precautionary reasons.[8] The key parameters are the discount factor and the risk aversion coefficient which respectively measures how patient the state governments are and how averse they are to downward changes in their consumption. These parameters will govern the consumer's consumption and savings behavior. Impatience causes the agent to consume more today while risk aversion causes them to save.

## 3.2 Mapping of Variables

In this section, we define what income. consumption, wealth and cash-on-hand are in the context of state governments. Because some states set their budget biannually, we treat two non-overlapping years as one time period for the remainder of the paper. The first

[7]This is possible due to the homotheticity of the utility function. Doing so allows us to eliminate permanent income as a state variable. See Carroll (1997).

[8]Because consumers can face zero income indefinitely, they do not want to borrow and risk driving their consumption to close to zero.

period in our sample is 1975 to 1976 where we take two years sums for flow variables such as revenue, expenditure, etc. and take one year lags for stock variables such as cash and security holdings, bond funds, other funds, etc. [9]

### 3.2.1 Income

We define state income as the component of their revenue which is determined by the amount of tax the state government collects from consumers and to some degree is exogenous to the state government. To obtain this, we estimate the regression

$$\Delta Revenue_{it} = \gamma_0 + \gamma_i \Delta PersonalIncome_{it} + \epsilon_{it} \tag{5}$$

where $PersonalIncome_{it}$ is the aggregate personal income of consumers in state $i$ at period $t$. We estimate the regression in growth because both revenue and personal income are unit roots.[10] State income is the fitted values of this regression in levels, $\widehat{Revenue}_{it}$, which we obtain by defining $\widehat{Revenue}_{i1} = Revenue_{i1}$ then recursively computing

$$Y_{it} \equiv \widehat{Revenue}_{it} = \Delta \widetilde{Revenue}_{it} + \sum_{j=2}^{t} \widehat{Revenue}_{ij-1} \tag{6}$$

[9] Craig et al. (2016) state that some state governments budget every two years and argue that those that do so annually respond to shocks with some lag. The latter adjust their tax and benefit scheme only at preset deadlines.

[10] Estimating this in levels will result in a spurious regression. Because we want to obtain the component of revenue that is explained by personal income, we avoid this.

where $\Delta\widetilde{Revenue}_{it}$ is the fitted value of the regression in differences.[11] We estimate the standard deviations of permanent and transitory shocks as well as permanent income from this series using the Kalman filter and smoother, respectively (see Section 5 for details and results).

### 3.2.2 Consumption

We follow Craig et al. (2016) and think of state consumption as political consumption. The components of political consumption are their current expenditure minus any discretionary taxes collected.[12] The discretionary tax is defined as the residual of the previous regression in levels given by

$$\widehat{u_{it}} = Revenue_{it} - \widehat{Y_{it}} \tag{7}$$

and state consumption is defined as

$$C_{it} \equiv CurrentExpenditure_{it} - \widehat{u_{it}} \tag{8}$$

The idea behind this is that policymakers receive political benefits from spending on projects that increase the utility of the representative consumer in their state or lowering taxes and incur a political loss if they increase taxes.

[11] We treat two years as one period and take non-overlapping sums (for flow variables such as income). The first period is 1975 to 1976. Once we obtain the whole series, we eliminate $\widehat{Revenue}_{i1}$ from the series because this is the initial value obtained from the data and not a residual.

[12] We do not include capital outlay because it is partly a consumption good and partly an investment good which should be modeled differently.

### 3.2.3 Wealth and Cash-on-Hand

In the data, states have various forms of assets that comprise their wealth. For our purposes, we define wealth and cash-on-hand as

$$W_{it} \equiv OtherFunds_{it} \tag{9}$$

$$COH_{it} = W_{it} + Y_{it} = OtherFunds_{it} + \widehat{Revenue}_{it} \tag{10}$$

respectively, where "other funds" is a subset of cash and security holdings in the data and cash-on-hand is the beginning of period resources available for consumption.[13] The reason for this is that most of states' assets are not easily accessible as a means to smooth consumption. For instance, a large fraction of cash and security holdings is comprised of pension fund assets and insurance trust assets. While these provide a store of wealth for state governments, these cannot be used for any purpose other than what they are designated for.[14] In our data set, the only assets that we cannot say for sure are subject to this are "other funds".[15]

[13] With the exception of Montana, all states have some form of Rainy Day Funds. Ideally, we would like to include this in our measure of wealth. However, the data from the Census Bureau does not delineate assets further than other funds and does not explicitly list all assets held. In an external data set, we find that Rainy Day Funds make up a small fraction of other funds. Furthermore, this data set only goes back to 1988 but Zhao (2016) finds that states have had similar funds that go back farther than this. Upon examining state legislation, we also find that these funds have existed since the 60's and maintain purposes similar to Rainy Day Funds but are occasionally renamed.

[14] We abstract from issues of fungibility.

[15] The components of cash and securities are social insurance fund assets (ie. pension fund assets, unemployment insurance assets, etc.), bond funds and offsets to debt and other funds. Other funds is the only component that we could not verify as earmarked.

# 4 Empirical Strategy

In this section, we describe our measure of permanent income which we use throughout the rest of the paper and the empirical test for Buffer Stock behavior.

## 4.1 Permanent Income

A key component of the Buffer Stock model is the income process which is a source of uncertainty for the consumer. Note that the income process imposed by the model is an unobserved components model where $P_t$ and $\epsilon_t$ are the unobserved components. The estimates for the standard deviations of the permanent and transitory shocks are usually obtained through GMM while the permanent component of income is usually defined as a three or five year moving average (see Craig et al. (2016)).[16] While we do not argue against doing these, we instead use the Kalman filter to estimate the standard deviations of the permanent and transitory income shocks and the Kalman smoother to estimate the permanent component of income to prevent data loss.[17] The measurement and transition equations are given by the logs of equations (3) and (4), respectively.[18]

[16]In some data sets such as the Survey of Consumer Finances interviewees are asked what is their typical income and their response to this question is taken as the permanent component.

[17]A three or five period moving average, which is generally taken to be the standard definition of permanent income, will make us lose four or eight years of data in addition to the one period (two years) lost from obtaining $\widehat{Y_{it}}$.

[18]See Appendix for state space representation.

### 4.2 Buffer Stock Regressions

To gauge for Buffer Stock behavior, we estimate the statistic innovated by Jappelli, Padula and Pistaferri (2008) (JPP) which they call the covariance ratio. This is defined as

$$\theta = \frac{Cov(coh_{it} - coh^*, c_{it})}{Cov(coh_{it} - coh^*, coh_{it})}. \tag{11}$$

They show that this satisfies the theoretical requirement (derived from the Buffer Stock model)

$$\theta > 1 - \frac{G}{(1+r)e^{\sigma_\psi^2}},$$

with the interpretation that if the deviation from target cash-on-hand, $coh_{it} - coh_i^*$, is positive then impatience will dominate risk aversion causing state governments to increase consumption and run down their savings (see Fig 7). Conversely, state governments would decrease their current consumption to accumulate savings when the deviation from the target is negative due to risk aversion dominating impatience. In practice, this is the IV estimator of a regression of $c_{it}$ on $coh_{it}$ using $coh_{it} - coh_i^*$ as an instrument which reflects how consumption will change based on deviations from target cash-on-hand.

### 4.3 Discussion of Results

Table 3 displays the means of the model variables as well as the average standard deviations across time and states. We see that the overall average of cash-on-hand is 1.136 times that of permanent income. The average standard deviation of cash-on-hand over time for the cash-on-hand is not as large as the average standard deviation across states which implies that states do not wish to deviate too far from their target savings.

The results of our empirical test (based on JPP) are presented in Table 4. Column 1 is the specification that JPP and Craig et al. (2016) estimate but with time fixed effects. We obtain a covariance ratio of 0.35 which is significant at the 5% level. For comparison, the estimate obtained by Craig et al. (2016) is 0.25.[19] The interpretation of this is that when the realized cash-on-hand is below (above) target, the government will decrease (increase) consumption and save (dis-save) until they reach their target.

Of particular interest is to study the role of Rainy Day Funds in smoothing consumption. By design, these funds are to be used by states in times of financial or economic distress. Column 2 reports the results of the previous regression when we include slope and intercept dummies for states that have Rainy Day Funds in a given year. We see that these Rainy Day Funds do not have a significant effect on consumption which implies that their role as Buffer Stock savings is minimal.

# 5 Model Estimation

In this section, we describe the calibration of the model, the estimation of the income process and the estimation of the behavioral parameters.

[19] Craig et al. (2016) estimate this with regards to unemployment insurance while JPP estimate this for consumers.

## 5.1 Calibrated Parameters

Outside of those that we estimate, the only parameters that we calibrate are the real interest rate, $r$, and the probability of zero income, $\omega$. We believe that in principle, states can never receive zero income so we set $\omega = 0.0001$ and explore other probabilities in the appendix.[20] We compute the interest rate as the average of real interest on general debt divided by real debt outstanding and obtain $r = 0.0346$.

## 5.2 Income Process

As discussed in previous sections, we use the Kalman filter to obtain the estimates of the standard deviations of permanent and transitory income shocks. Table 5 presents the estimation results from the Kalman filter. The standard deviation of permanent shocks is 0.0440 while the standard deviation of the transitory shocks is 0.0495. Figure 6 plots the aggregate estimated permanent income over time and income.

## 5.3 Preference Parameters

The parameters of interest are the discount factor $\beta$ and $\rho$, which govern consumption and savings behavior of states, using Simulated Method of Moments. We refer the reader to Gourinchas and Parker (2002) who provide a thorough discussion of the econometric theory. The moments we use for estimation are the average target wealth to permanent income ratio across states and the covariance ratio. The target cash-on-hand for a state in the data is

[20] Carroll (1997) finds that the probability of near zero income is around 0.5%. Craig et al. (2016) assume that for state governments, the probability of zero income is 0.001 at its lowest.

computed as the average cash-on-hand to permanent income ratio for that state over time. Because we have exact identification, we use an identity weighting matrix. Standard errors are obtained by bootstrapping. Details of the simulation, model solution and bootstrapping are explained in the appendix.

### 5.4 Discussion of Results

Table 6 presents the fit of the model and the estimates of $\beta$ and $\rho$. We see that the model fits the data very well. Estimates of the discount factor and CRRA parameter from consumer data are generally between 0.92 and 0.96 and between 2.5 and 4, respectively (see Cagetti (2003) and Gourinchas and Parker (2002)).[21] Our estimates are within these ranges with a discount factor of 0.949 and risk aversion coefficient of 3.027 although we find that risk aversion is significant only at the 10% level. These suggest that state governments are impatient and risk averse causing them to engage in some form buffer stock behavior while our empirical results suggest that Rainy Day Funds do not play a significant role in this.

## 6 Conclusion

This paper examines the success of US states at smoothing public consumption over the business cycle. The question is motivated by two competing ideas. First, countries around the world are seeking to impose greater budgetary discipline on their governments, and are imposing budget constraints (IMF, xxx). Second, however, in the U.S. states are creating

[21] Depending on the moments used in estimation and the measure of wealth, the discount factors can go as low as 0.88 and as high as 1.2 while risk aversion can go as low as 0.85 and as high as 7.

Rainy Day Funds as explicit mechanisms to use assist with inter-temporal smoothing. Thus, our paper explores whether the new savings institution of RDFs is needed, and then goes farther to ask whether indeed state governments succeed at smoothing consumption over the business cycle.

The answer to our question is that state governments appear to be, compared to conventional wisdom, surprisingly responsible. This conclusion obtains from estimation of a buffer stock model of state government behavior. Using the panel of fifty US states from 1976-2010, we find from simulation using the GMM estimates a two-year discount rate of 0.949, and a coefficient of risk aversion of 3.027. These values suggest that government officials demonstrate little impatience as they act "as if" the market real interest rate is 2.6%.

One interesting fact uncovered here is that state governments have evolved mechanisms to allow them to smooth consumption over time, despite that on the surface, balanced budget rules would be a binding constraint. Our finding is consistent with analysis in Poterba (1994) that finds a broad variation in coverage in the exact mechanism created by the balanced budget rules. Our analysis also suggests that recently created rainy day funds are an explicit recognition of a mechanism that is already implicit in state budgeting, and at least on average RDFs do not increase the ability of states to do what they have been doing for a long time.

A pertinent policy question raised by our research is to consider whether governments should have greater constraints on their behavior. Balanced budget constraints were initially targeted to prevent borrowing for current consumption. Our work does nothing that says such constraints are not a good idea. On the other hand, on average governments have avoided savings plans [22]. Government savings have the potential of significant dead-weight loss in a mobile society, as those paying into a savings plan may not benefit from the use of those tax-financed resources. On the other hand, our analysis shows that government management of savings accounts has the possibility of being responsible- even potentially more responsible than a significant portion of the population Jappelli, Padula and Pistaferri (2008). Thus, it is possible that creating government saving mechanisms may be Pareto improving.

[22]Even to the extent of using pay-as-you-go social security systems

# References

**Cagetti, Marco.** 2003. "Wealth Accumulation over the Life Cycle and Precautionary Savings." *Journal of Business & Economic Statistics*, 21(3): 339–353.

**Cameron, A Colin, Jonah B Gelbach, and Douglas L Miller.** 2008. "Bootstrap-based improvements for inference with clustered errors." *The Review of Economics and Statistics*, 90(3): 414–427.

**Carroll, Christopher D.** 1992. "The Buffer-Stock Theory of Saving: Some Macroeconomic Evidence." *Brookings Papers on Economic Activity*, 23(2): 61–156.

**Carroll, Christopher D.** 1997. "Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis." *The Quarterly Journal of Economics*, 112(1): 1–55.

**Carroll, Christopher D.** 2001. "Death to the Log-Linearized Consumption Euler Equation! (And Very Poor Health to the Second-Order Approximation)." *The B.E. Journal of Macroeconomics*, 1(1).

**Carroll, Christopher D.** 2006. "The method of endogenous gridpoints for solving dynamic stochastic optimization problems." *Economics Letters*, 91(3): 312 – 320.

**Craig, Steven G, Wided Hemissi, Satadru Mukherjee, and Bent E Sørensen.** 2016. "How do politicians save? Buffer-stock management of unemployment insurance finance." *Journal of Urban Economics*, 93: 18–29.

**Deaton, Angus.** 1991. "Saving and Liquidity Constraints." *Econometrica*, 59(5): 1221–1248.

**Domeij, David, and Martin Flodén.** 2006. "The labor-supply elasticity and borrowing constraints: Why estimates are biased." *Review of Economic Dynamics*, 9(2): 242 – 262.

**Gourinchas, Pierre-Olivier, and Jonathan A. Parker.** 2002. "Consumption Over the Life Cycle." *Econometrica*, 70(1): 47–89.

**Jackson, Matthew O., and Leeat Yariv.** 2014. "Present Bias and Collective Dynamic Choice in the Lab." *American Economic Review*, 104(12): 4184–4204.

**Jappelli, Tullio, Mario Padula, and Luigi Pistaferri.** 2008. "A Direct Test of the Buffer-Stock Model of Saving." *Journal of the European Economic Association*, 6(6): 1186–1210.

**Phelan, Christopher, and Manuel Amador.** 2017. "Reputation and Sovereign Default." Society for Economic Dynamics 2017 Meeting Papers 1167.

**Poterba, James M.** 1994. "State Responses to Fiscal Crises: The Effects of Budgetary Institutions and Politics." *Journal of Political Economy*, 102(4): 799–821.

**Schechtman, Jack.** 1976. "An income fluctuation problem." *Journal of Economic Theory*, 12(2): 218 – 241.

**Zeldes, Stephen P.** 1989. "Optimal Consumption with Stochastic Income: Deviations from Certainty Equivalence*." *The Quarterly Journal of Economics*, 104(2): 275–298.

**Zhao, Bo.** 2016. "Saving for a rainy day: Estimating the needed size of US states budget stabilization funds." *Regional Science and Urban Economics*, 61(2016): 130–152.

# 7 Appendix

## 7.1 Other Data

In addition to the breakdown of government finances, we also have data on state level aggregates on population, Consumer Price Indices, personal income and the years when Rainy Day Funds (and their predecessors) have first balance. Population data is from the Census Bureau where non-census year estimates are adjusted by the average growth rate between census years. CPI data for all items in the US is obtained from FRED. The data on personal income is taken from the Bureau of Economic Analysis. The years when Rainy Day Funds (and their predecessors) have first balance are taken from the fiscal survey of states provided by the National Association of State Budget Officers (NASBO).

## 7.2 State Space Representation of the Income Process

In order to implement the Kalman filter, we must reformulate the statistical model in state space form. This includes a transition equation which describes the evolution process of the the state variable and a measurement equation which describes how the latent state variables affect the observed variables each period. The general form of the transition equation is

$$\alpha_t = K\alpha_{t-1} + R\eta_t \tag{12}$$

where K and R are matrices of constants and $\eta_t \sim N(0, Q)$. While the general form of the measurement equation is

$$m_t = Z\alpha_t \tag{13}$$

where Z is again a constant matrix. For our analysis we will be estimating the income process which has a permanent component which follows a random walk as well as the transitory component which follows an i.i.d process. The log of the income process is

$$log(Y_t) = log(P_t) + u_t \tag{14}$$

$$log(P_t) = log(P_{t-1}) + e_t \tag{15}$$

where we take equation (14) as the measurement equation and equation (15) as the transition equation with $u_t = log(\epsilon_t)$ and $e_t = log(\psi_t)$.

The state space representation of this income process consists of states

$$\alpha_t = \begin{pmatrix} e_t \\ u_t - u_{t-1} \\ -u_t \end{pmatrix} \qquad \eta_t = \begin{pmatrix} e_t \\ u_t \end{pmatrix}$$

where the restriction matrices are

$$K = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix} \qquad Z = \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix} \qquad R = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 0 & -1 \end{pmatrix}$$

The transition equation is then

$$\begin{pmatrix} e_t \\ u_t - u_{t-1} \\ -u_t \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} e_{t-1} \\ u_{t-1} - u_{t-2} \\ -u_{t-1} \end{pmatrix} + \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} e_t \\ u_t \end{pmatrix}$$

where the covariance matrix of the error terms is

$$Q = \begin{pmatrix} \sigma_p^2 & 0 \\ 0 & \sigma_t^2 \end{pmatrix}$$

where $\sigma_\psi^2$ is the variance of permanent shocks and $\sigma_\theta^2$ is the variance of transitory shocks.

Given the state space representation of the statistical model, the Kalman filter proceeds by predicting the current state and conditional covariance matrix of the prediction errors based on past states, computing the loglikelihood function conditional on past observations then updates the states given current and past observations and the conditional covariance matrix of the states given the updated states. We perform the estimation in two steps. In the first step, we initialize states at zero. In the second step, we initialize at the stationary distribution. The estimates are reported in table 5.

The Kalman smoother estimates the unobserved states by backward forecasting given the Kalman filter estimates of the parameters of the distribution of the process and states.

### 7.3 SMM Estimation

We are interested in inferring the behavioral parameters of the model given the estimated covariance ratio and average target cash-on-hand. In order to do this, we must simulate and estimate the model using Simulated Method of Moments.[23] The SMM estimator is defined as

$$\hat{\beta} = argmin((m^d - m^s(\beta))'W(m^d - m^s(\beta)))$$

where W is a weighting matrix, $m^d$ is a vector of moments computed from the data and $m^s$ is a vector of moments computed from simulated data. In line with our goal, we take the covariance ratio and the average target cash-on-hand as our moments. Since we have exact identification, we take an identity weighting matrix.

[23]An alternative approach to recovering $\beta$ and $\gamma$ is to estimate these by log linear approximation of the Euler equation. However, a number of papers have argued that such approximations lead to biased estimates because they ignore constraints. See Carroll (2001) and Domeij and Flodén (2006). Such an issue might produce estimates that are consistent with the theoretical constraint that the covariance ratio satisfies.

## 7.4 Bootstrap Standard Errors

To compute the standard errors for our SMM estimates, we use a cluster bootstrap where clustering is done by state.[24] Given our data set, we generate 200 bootstrap samples. In each bootstrap sample a draw of a state is made with replacement until the bootstrap sample is the same size as the original data set. For each of these draws, we take the whole time series of all variables. For each bootstrap sample, we recompute the moments for estimation then re-estimate the model for each sample. The bootstrap standard errors are then the standard deviation of these estimates.

## 7.5 Numerical Solution and Simulation

The model is solved using the method of endogenous grid points developed by Carroll (2006). We first set an exogenous grid of end of period $t$ assets, $a_t$, which is defined as

$$\begin{aligned} a_t &= coh_t - c_t \\ &= w_t + y_t - c_t \end{aligned}$$

where $coh_t$ is cash-on-hand (beginning-of-period market resources available for consumption), $w_t$ is financial wealth and $c_t$ is beginning-of-period consumption.[25] At these asset grid points, we compute the end of period marginal value functions which is equal to the present discounted value of expected marginal utility next period. We then invert the Euler equation

[24]See Cameron, Gelbach and Miller (2008) for a more detailed explanation of the theory.
[25]Perhaps a more familiar notation to readers is to take $w_t = (1 + r)a_{t-1}$

to obtain $c_t$:

$$c_t = u'^{-1}(\beta(1+r)\mathbb{E}_t u'(c_{t+1})) = u'^{-1}(\beta(1+r)\mathbb{E}_t V'(a_t)) \tag{16}$$

where the equivalence of the marginal utility and marginal value functions is due to the envelope condition.[26] We then back out the value of cash-on-hand associated with $c_t$:

$$coh_t = c_t + a_t \tag{17}$$

This gives us the pair $\{coh_t, c_t\}$ with which we can interpolate $c_{t+1}$ given $a_t$.[27]

We use a triple exponential grid for end-of-period assets to capture the concavity of the consumption function with 300 grid points. For evaluating expectations, we discretize the distributions of the permanent and transitory shocks using Gauss-Hermite quadrature, each with 9 nodes (the zero income shock is the $10^{th}$ point for the transitory shocks). We simulate 50 agents who start out with zero wealth for 5000 periods.[28]

[26] To initialize the algorithm, we make an initial guess of the period $t$ cash-on-hand and consumption functions. Next period consumption is then obtained by linear interpolation.

[27] We use linear interpolation. For points that lie outside of the grid, we extrapolate.

[28] We simulate 10000 periods then burn the first half of the observation to reduce the influence of the initial value.

### 7.6 Tables

Table 1: Summary Statistics (per Capita)

| | | |
|---|---|---|
| Total Revenue | Mean | 11043 |
| | Std$_c$ | 4821 |
| | Std$_t$ | 2466 |
| Current Expenditure | Mean | 9349 |
| | Std$_c$ | 3249 |
| | Std$_t$ | 2276 |
| Other Funds | Mean | 2574 |
| | Std$_c$ | 7303 |
| | Std$_t$ | 989 |
| Own Revenue | Mean | 8435 |
| | Std$_c$ | 4247 |
| | Std$_t$ | 1835 |
| Total Expenditure | Mean | 10201 |
| | Std$_c$ | 3634 |
| | Std$_t$ | 2392 |
| Cash and Security Holdings | Mean | 10335 |
| | Std$_c$ | 10253 |
| | Std$_t$ | 3989 |
| Observations | | 800 |

Note: This table displays the summary statistics for the raw per capita data from 1975 to 2010 in 2015 dollars. "Std1" denotes the time average of the standard deviation across states which is $\left[(1/n)\sum_i \left(X_{it} - \overline{X_t}\right)^2\right]^{\frac{1}{2}}$ for any variable $X$. $\overline{X_t}$ is the period $t$ average of $X_{it}$ across states. $n$ is the number of states. "Std2" denotes the cross sectional average of the standard deviation over time which is $\left[(1/T)\sum_t \left(X_{it} - \overline{X_i}\right)^2\right]^{\frac{1}{2}}$. $\overline{X_i}$ is the time average of $X_{it}$ for states $i$ and $T$ is the number of years in the sample.

Table 2: Growth Rates During Recessions

| | Recession Years | | | |
|---|---|---|---|---|
| | 1979-81 | 1989-91 | 2000-01 | 2008-10 |
| Revenue | 0.36 | 2.63 | -15.55 | 47.92 |
| Other Funds | -3.63 | -1.74 | 0.08 | -3.92 |
| Rainy Day Funds | 0 | -0.27 | -0.94 | -1.35 |
| Intergovermental Revenue | -0.19 | 2.85 | 3.14 | 13.91 |
| Current Expenditure | 2.54 | 8.88 | 8.96 | 19.42 |
| Debt | -24.98 | -3.36 | -0.48 | 9.83 |

Note: The table presents the average growth rates of select variables during recessions. Values reported are in percent. Rainy day fund data are reported as 0% in 1979-1981 because we do not have the amounts for these years.

Table 3: Descriptive Statistics of Buffer Stock Model Variables

| | Means | Std Dev. 1 (Cross-section) | Std Dev. 2 (Time-series) |
|---|---|---|---|
| Cash-on-hand/Permanent income | 1.136 | 0.242 | 0.06 |
| Income/Permanent income | 0.978 | 0.012 | 0.038 |
| Consumption/Permanent income | 0.83 | 0.093 | 0.073 |
| Observations | 800 | 800 | 800 |

Note: This table displays the summary statistics for the model data. We treat two years as one period. For flow variables, we take the sum of the two years. For stock variables we take the one year lag. The first period in the sample is from 1975 to 1976. We lose this first period in obtaining our definition of income. We also lose the second period from 1977 to 1978 when estimating permanent income. The first period used for estimation is from 1979 to 1980. Std1 denotes the time average of the standard deviation across states. Std2 denotes the cross sectional average of the standard deviation over time. All variables are normalized by permanent income.

Table 4: **Buffer Stock Regressions**

| | c | c |
|---|---|---|
| coh | 0.351*** | 0.579*** |
| | (0.096) | (0.093) |
| RDF Dummy × coh | | -0.240 |
| | | (0.193) |
| RDF Dummy | | 0.260 |
| | | (0.205) |
| Constant | 0.405*** | 0.154 |
| | (0.117) | (0.096) |
| Time FE | Yes | Yes |
| N | 800 | 800 |

* 10% level of significance.

** 5% level of significance.

*** 1% level of significance.

Note : This table presents the estimates of the covariance ratio defined in Jappelli, Padula and Pistaferri (2008). Consumption (normalized by permanent income), c, is expenditure of the state governments and cash-on-hand (normalized by permanent income), coh, is sum of other funds and the fitted values from a regression of revenue on personal income. Column 1 presents the IV estimates of $c_{it} = \alpha + \theta coh_{it} + \epsilon_{it}$ where the instrument is $coh_{it} - coh_i^*$ and $coh_i^*$ is the target cash-on-hand. Column 2 presents the IV estimates with intercept and slope dummies for states in years which they have Rainy Day Funds. Time fixed effects are included in both regressions. Flow variables are taken as two year sums while stock variables are taken as one year lags. We lose the first period from obtaining the measure of income and we lose the second observation from obtaining permanent income. All variables are normalized by permanent income. Standard errors clustered by state are in parenthesis.

Table 5: **Kalman Filter Estimates**

| Parameter | Estimate |
|---|---|
| $\sigma_\psi$ | 0.0440*** |
| | ( 0.0038) |
| $\sigma_\theta$ | 0.0495*** |
| | (0.0030) |

* 10% level of significance.
** 5% level of significance.
*** 1% level of significance.

Note: This table displays the Kalman filter estimates of the standard deviations of permanent and transitory shocks, $\sigma_\psi$ and $\sigma_\theta$, respectively. Standard errors are computed using the empirical Hessian.

Table 6: **SMM Estimates and Model Fit**

| Parameter | Estimate | |
|---|---|---|
| $\beta$ | 0.949*** | |
| | ( 0.022) | |
| $\rho$ | 3.027* | |
| | (1.602) | |
| Model Fit | | |
| Parameter | Data | Model |
| Target Cash-on-Hand | 1.136 | 1.136 |
| Covariance Ratio | 0.351 | 0.351 |

* 10% level of significance.
** 5% level of significance.
*** 1% level of significance.

Note: This table displays the simulated method of moments estimates of the behavioral parameters and the model fit. The moments targeted are the average target cash-on-hand across states and the covariance ratio defined in Jappelli, Padula and Pistaferri (2008). In the data, target cash-on-hand for a given state, $coh_i^*$, is defined as the average cash-on-hand over time. The covariance ratio is the IV estimate of the coefficient of cash-on-hand from the regression $c_{it} = \alpha + \theta coh_{it} + \epsilon_{it}$ where $c_{it}$ is consumption and $coh_{it}$ is cash-on-hand and is instrumented by $coh_{it} - coh_i^*$. In the model, target cash-on-hand for an agent is defined as $coh_i^*$ such that $\mathbb{E}(coh_{it+1}) = coh_{it}$. The average target cash-on-hand is computed as the average $coh_i^*$ across agents. The covariance ratio in a given time period is $\theta_t = \frac{cov(coh_{it} - coh_i^*, c_{it})}{cov(coh_{it} - coh_i^*, coh_{it})}$. The moment is then computed as the average of this over time. Flow variables in the data are taken as two year sums while stock variables are taken as one year lags. We lose the first period from obtaining the measure of income and we lose the second observation from obtaining permanent income. All variables are normalized by permanent income which is estimated using the Kalman smoother. Standard errors in parenthesis are computed by bootstrap.

## 7.7 Figures

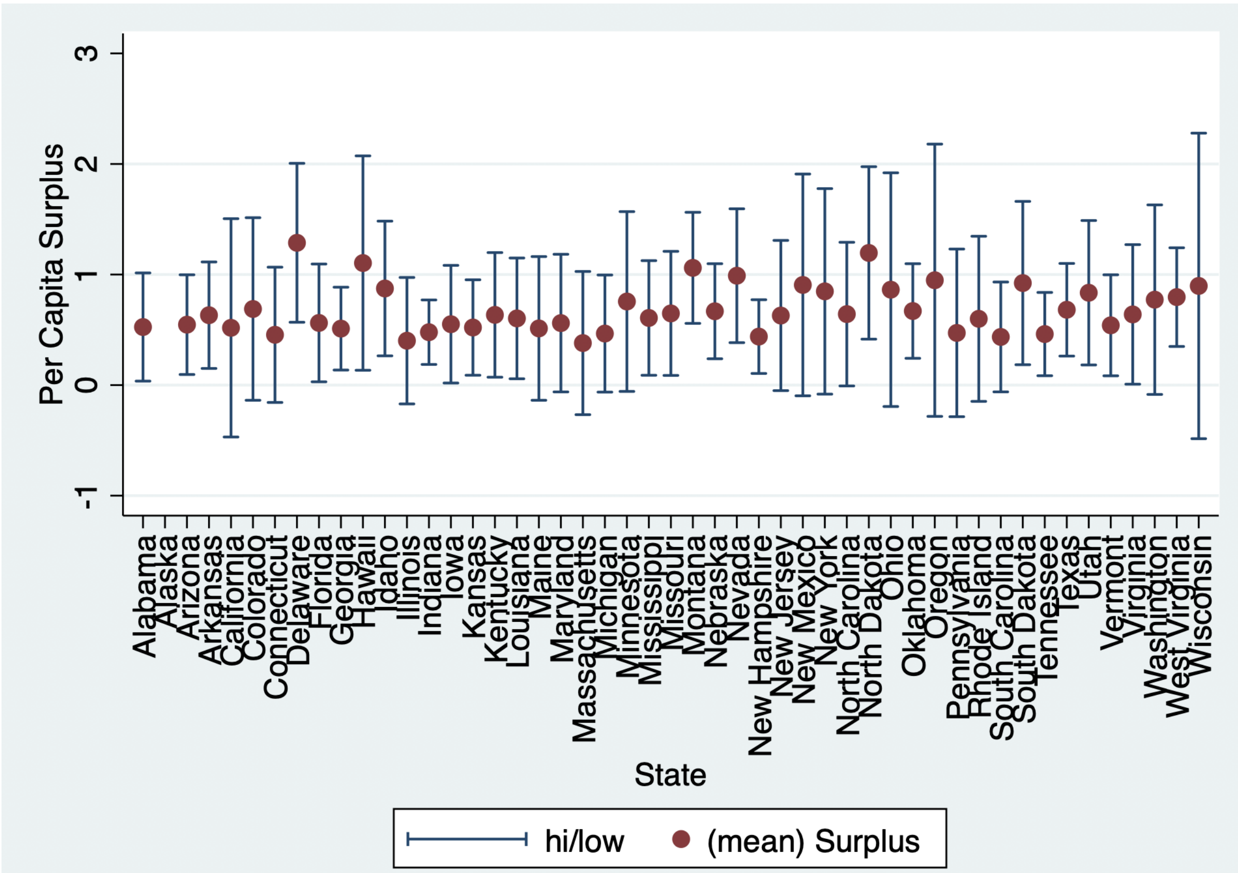


Figure 1: Mean of Surpluses in Billions of Dollars (2015 Dollar terms) during the period 1975-2010. The bars are one standard deviations above and below the mean. Surplus = (Total Revenue - Current Expenditure)/State Population. hi/low indicate the upper bound and lower bound of $\bar{X} \pm \sigma$, where $\bar{X}$ is mean surplus and $\sigma$ is the standard deviation for each state across time. The values for Alaska and Wyoming were 6 and 2.3 which are much higher than the rest of 48 states and hence not reported in the figure. This is primarily due to income from oil and natural resources.

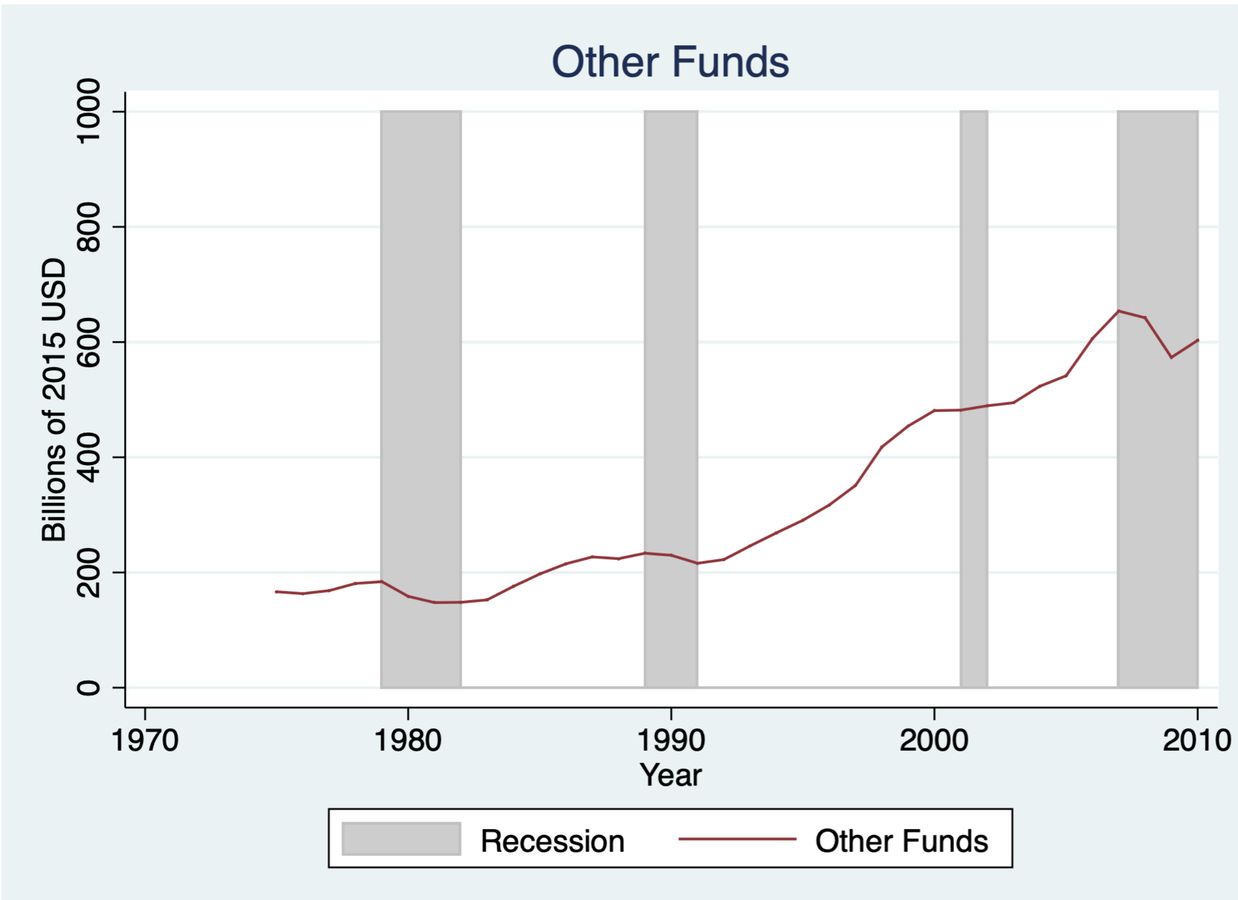


Figure 2: Other Funds aggregated across states from 1975-2010. Values are in 2015 Billions of US dollars

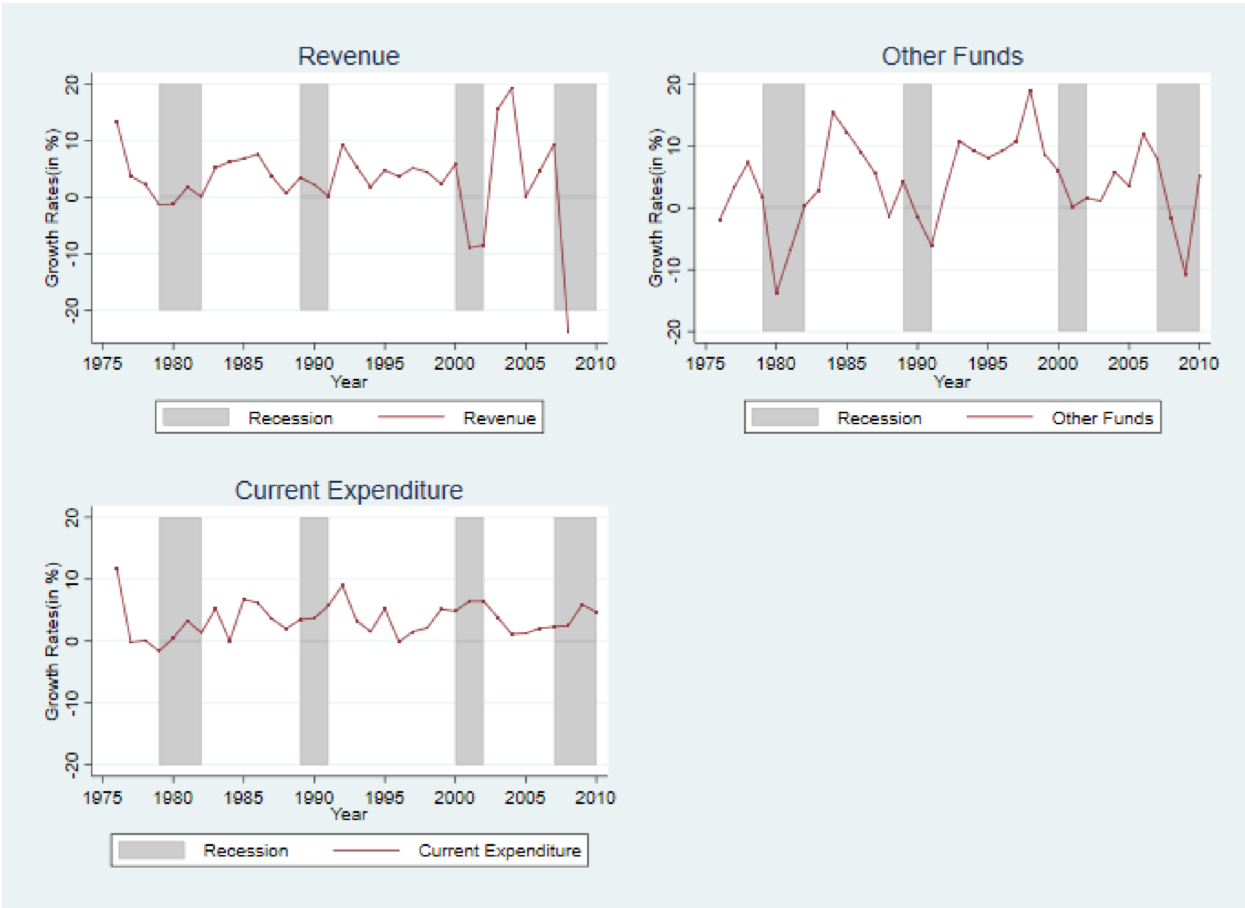


Figure 3: Growth Rates of State Income and Expenditure

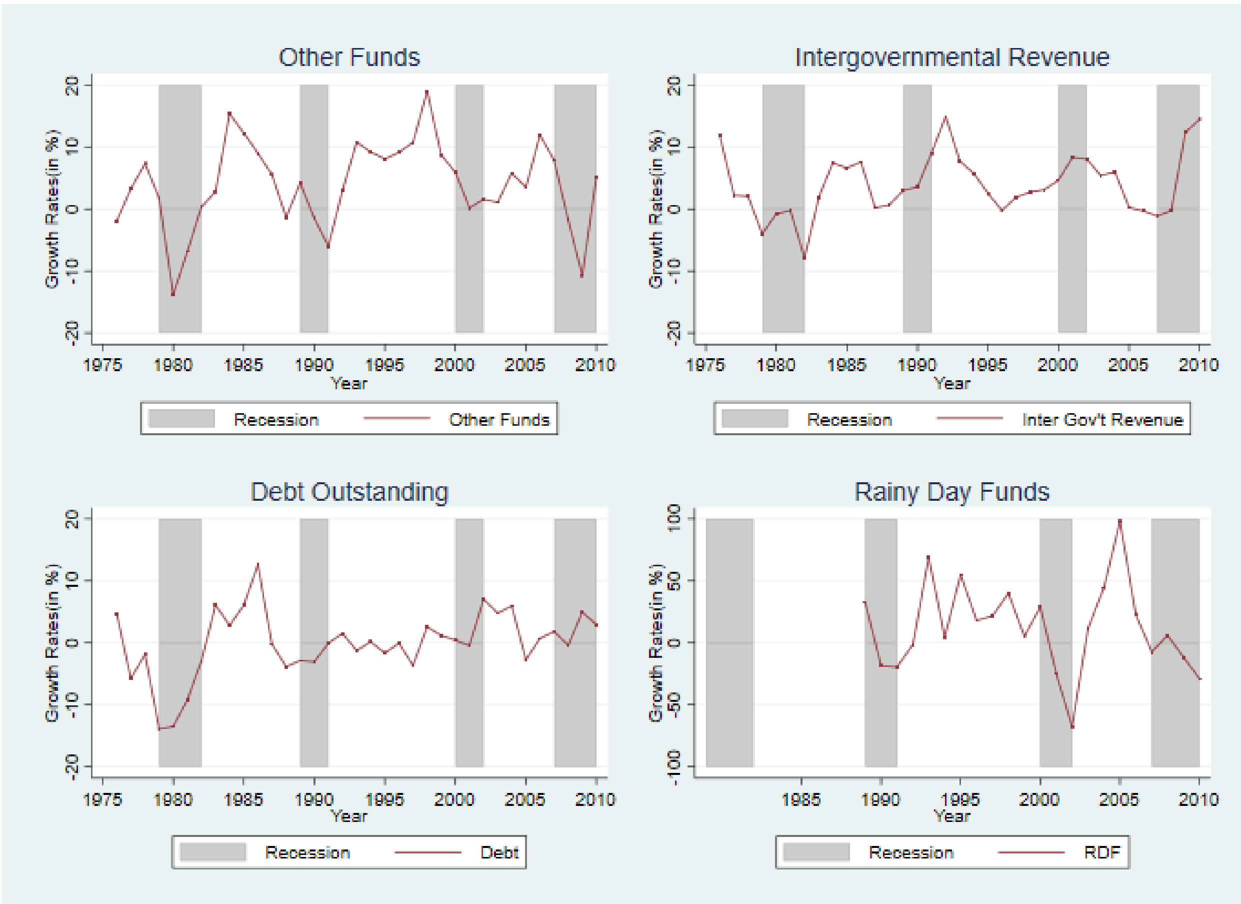


Figure 4: Growth Rates of Revenue Components, Debt and Rainy Day Funds

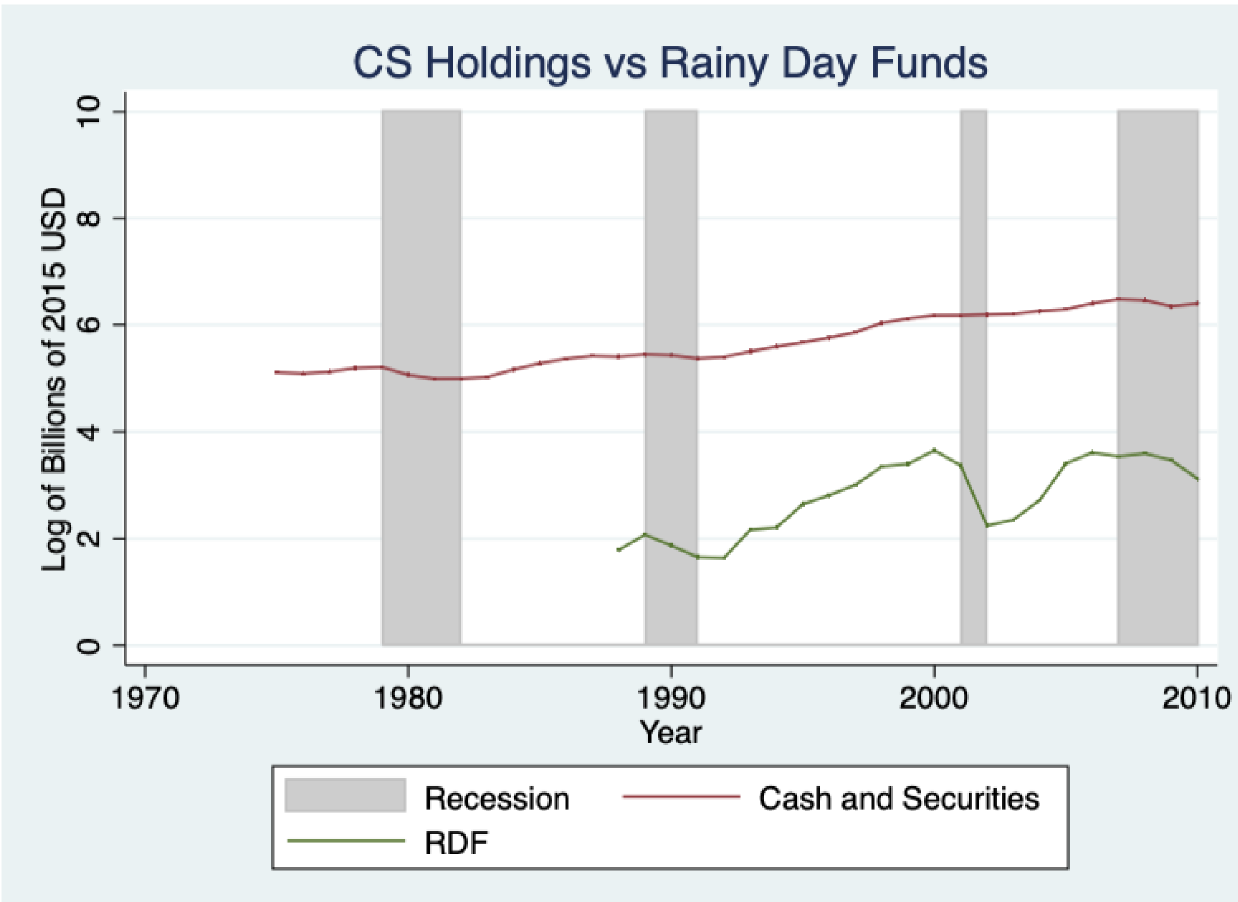


Figure 5: RDfs plotted against Cash and Security holdings which constitute the "Other Funds" held by state governments

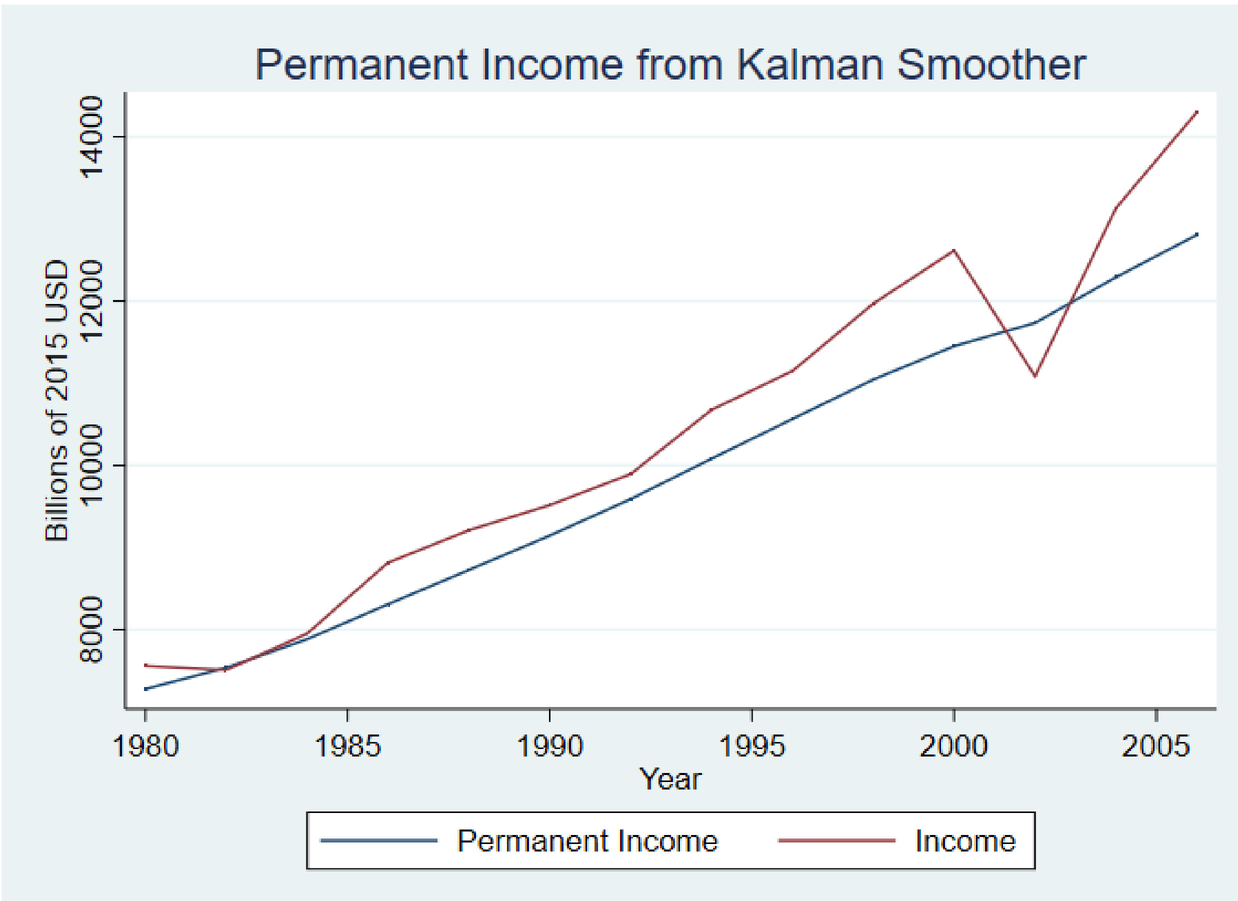


Figure 6: Permanent income and actual income from Kalman Filter for the US States

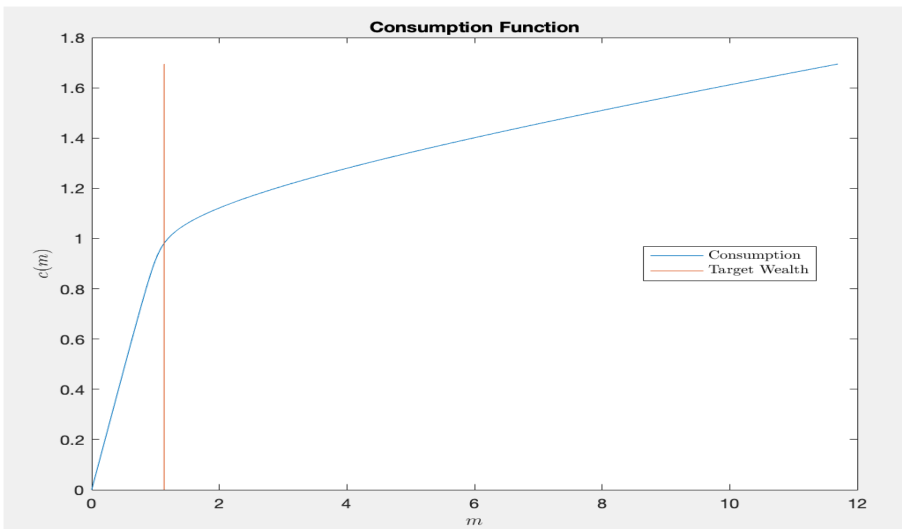


Figure 7: Consumption plotted as a function of cash on hand along with the target cash on hand. m in the above figure is cash on hand. This graph is based on our estimates of $\beta$ and $\rho$