Federalism, fiscal savings, and information asymmetries

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Abstract

A key motivation underlying fiscal unionization is the smoothing of risk across heterogeneous regions. In the U.S., however, transfers from federal to state governments respond more strongly to aggregate cycles than state-level cycles; unsurprisingly, more independent U.S. states engage in more precautionary savings. A model in which two governments enact fiscal policy, the 'regional' government has credit constraints, and the 'central' government's information is imperfect, matches the data and implies a sizable information friction. The central government's inability to respond to idiosyncratic shocks implies a role for states in countercyclical policy, despite limitations, and provides caution to centralized fiscal unions.

Keywords: fiscal policy, fiscal federalism, fiscal union, information asymmetries, business cycles, precautionary savings.

JEL codes: C73, D83, E21, E62, F41, H3, H7

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1 Introduction

The United States is an important example of fiscal federalism and fiscal unionization. One of the main purposes of fiscal unionization is thought to be the ability of a fiscal union to smooth idiosyncratic risks among its member jurisdictions (Farhi and Werning, 2017). The U.S. is a strong version of a fiscal union: the central government enjoys full tax and spending power. One might expect that such a fiscal authority would fully insure subnational governments against risk; however, this may not be the case if the central government itself faces significant frictions. The behavior of state governments and the federal government in the U.S. provides a useful case study to examine how fiscal policy is conducted by members of a strong federation.

Fiscal policy at the state level is an important component of the economic environment in the U.S. Spending by subnational governments totaled 2.85 trillion dollars in 2016, representing almost 15 percent of GDP; state government spending alone made up 28 percent of total government spending.[2] In addition, the makeup of state government spending is fundamentally different than that of the federal government. While federal government spending primarily constitutes defense, social security, and interest payments, state governments tend to spend primarily on education and public welfare (this includes Medicaid). Constraints faced by state governments differ substantially from the federal government, as well; state governments interact with different tax bases, and most face deficit limits of varying strengths.

[2] BEA, 2018.

In light of these observations, policy analysts should not expect state-level fiscal policy to behave like federal policy. One major way in which state governments differ from the U.S. government is in the use of Budget Stabilization Funds, or "Rainy Day Funds", to improve funding for public programs in times of fiscal distress. All fifty state make use of rainy day funds; in 2017, Montana became the fiftieth state to establish such a fund.[3] The median balance of these funds in 2016 was 477 million dollars, having built up significantly since their depletion after the Great Recession. The presence and size of these funds indicates that fiscal savings may be an important way in which U.S. states can enact fiscal policy over the business cycle, even in the presence of (sometimes strict) deficit limits.

Motivated by the presence of a savings motive for states, especially given membership in a strong fiscal union, this paper seeks to answer three main questions. First, how do U.S. state governments respond to business cycles, what factors are important in determining these responses, and how does the federal government potentially influence states' incentives? Second, upon characterizing some patterns of fiscal behavior, what sort of a model might be able to reproduce that behavior and make meaningful predictions? Finally, what are the welfare implications of various policies and frictions that might exist in such a model?

[3] https://www.pewtrusts.org/en/research-and-analysis/articles/2018/08/29/states-make-more-progress-rebuilding-rainy-day-funds

1.1 Overview of results

The broad results are as follows. I present three stylized facts about state public finances over the business cycle: states engage in precautionary savings, transfers from the federal government respond less to local shocks than national shocks, and states whose cycles are less correlated with the national cycle tend to save more. I obtain these facts using data on state government finances from two different sources, under four possible definitions of state government savings; the results are robust to the choice of definition for state government savings.

I interpret these facts as evidence that state government savings behavior is driven both by balanced budget rules and by the transfer policies of the federal government. To illustrate, I propose a model of a small open endowment economy in a fiscal union; i.e., an economy under both a regional government and a central government, much like a U.S. state. The regional government faces a debt limit, but the central government observes the state of the world with a noisy signal. The central government, therefore, is not able to fully insure the regional household against adverse shocks, and the regional government must build up a stock of savings.

I calibrate the model to U.S. data, and find that it fits qualitative features of the data quite well. The implied noise shock in the central government's signal is almost three times as large as the real economic shocks, indicating significant frictions to optimal policy making at the centralized level. The baseline calibration of the model implies a 2.1 percent welfare loss relative to the social planner solution, indicating a sizeable influence of the frictions in the model on household utility. Two variations to the information structure of the central government yield very similar results to the baseline model. I conclude that information (or other political) frictions at the centralized level of policy making may create large deviations from the socially optimal policy; this implies states should consider actively pursuing countercyclical fiscal policies. Additionally, the results suggest that significant barriers to cross-region risk sharing may still exist, even in the presence of a strong fiscal union.

1.2 Literature and outline

This paper connects to a number of distinct strands of literature in economics research. On the empirical side, Hines Jr (2010) characterizes the behavior of state-level spending over the business cycle, arguing that small and large states behave differently in response to macroeconomic conditions. Nakamura and Steinsson (2014) estimate government spending multipliers for U.S. states, using military spending shocks from the central government. Owyang and Zubairy (2008) find heterogeneous effects of fiscal stimulus in different states and regions of the union, depending on regional makeup. In addition to these, Chodorow-Reich (2017) summarizes findings from empirical literature on the effects of fiscal policy at subnational levels.

In the public finance literature, economies with fiscal federalism have been much studied (Oates, 2008). This literature tends to compare public goods provision at the local level to that at the central level. These models are static, however, and do not say much about cyclical policy. Furthermore, they tend to compare two methods of public spending rather than having both local and central governments spending at the same time. For the purposes of this model, I abstract from the choice of public goods and study the optimal taxation behavior of states subject to an exogenous stream of public goods. This is the approach taken by optimal fiscal policy papers such as Schmitt-Grohe and Uribe (2004), Chari and Kehoe (1999), and Bhandari et al. (2017).

This paper also draws on the precautionary savings under credit constraints literature. Aiyagari (1994) is a key early example of this literature. Additionally, papers such as Bianchi and Mendoza (2018) and Durdu, Mendoza, and Terrones (2009) analyze savings decisions and credit contraints explicitly in small open economy models; I take this approach, though the optimizing agents of interest in my model are governments, while households are passive. Bhandari et al. (2017) consider explicitly fiscal policy for a credit constrained government with access to imperfect markets. I contribute to this literature by considering the problem of a government conducting fiscal policy under debt limits, but in a small open economy when there is a "higher" level of government which is also conducting policy, i.e., in a fiscal union or federation.

Other papers have studied fiscal policy in the context of a union of economies. Beetsma and Jensen (2005), Debrun (2000), and Ferrero (2009) consider optimal fiscal policy for economies in a monetary union. Luque, Morelli, and Tavares (2014) and Farhi and Werning (2017) consider the desirability of explicit fiscal unionization. This paper considers the strongest version of a fiscal union, in which the central government has full power to tax and spend in addition to the regional governments; this is the system in place in the U.S.

Models in which a central government might not have the same access to information as local governments have been explored in other contexts. Bordignon, Manasse, and Tabellini (2001), for example, consider optimal redistribution policy when information is asymmetric. Silva and Cornes (2000) examine information asymmetries in the context of interregional transfers and public goods provision. In his survey of the future of the fiscal federalism literature, (Oates, 2005) also mentions information asymmetries between the different levels of government as a feature of federal systems. This paper contributes to the information asymmetries literature in fiscal federalism by applying the idea to a dynamic model of fiscal policy.

The rest of the paper proceeds as follows. Section 2 presents the main stylized facts of the paper. Section 3 introduces the information model with which the stylized facts are interpreted. Section 4 calibrates, analyzes, and interprets the model. Section 5 concludes.

2 State government savings: three stylized facts

This section lays out three stylized facts apparent in the data on U.S. state government savings. First, state governments overwhelmingly engage in precautionary savings: savings are positive and procyclical. Second, transfer receipts from the federal government are countercyclical, but depend more on the aggregate U.S. economy than on a state's idiosyncratic business cycle. Finally, states whose business cycles are less correlated with the national business cycle tend to save more than states experiencing fluctuations more in step with the aggregate cycle. This section first describes the data sources and definitions; the second subsection presents the three facts.

2.1 Data and descriptions

2.1.1 Data sources

Several sources are used to assemble the data for this part of the paper. Data on rainy day funds and end-period balances for state governments are obtained from the National Association of State Budget Officers' - hereafter, NASBO - "Fiscal Survey of the States." I use the spring edition of this semiannual report from 1979 to 2017 to obtain data from previous years which is self-reported by states and collected by NASBO. Due to heterogeneity in the structure of BSFs, some state governments do not report BSF balances separately from end-year balances, rendering analysis of rainy day funds alone a bit hairy; I discuss this below when considering all possible definitions of 'savings.'[4]

Data on state government revenues, spending, and debt holdings comes from the U.S. Census Bureau's "Census of Governments." While the full sample of local governments is only administered every five years, all state governments are included in the limited survey taken every year, such that yearly observations from 1970 to 2012 are available for every state. Other state variables of interest are provided at the yearly level on the website of the University of Kentucky's Center for Poverty Research. I estimate state-level recession dates using the Philadelphia Fed's state coincident index. National annual price level indices are

[4] An appendix containing a full explanation of the data collection from NASBO reports is available upon request.

obtained from the OECD.

2.1.2 Definition of savings

In order to study the cyclical behavior of state government savings, some definition of 'savings' is naturally required. Four potential definitions are available in the data; I choose to focus on a couple of them for ease of exposition. The first obvious definition of state government savings is the balance of the state's rainy day fund as reported to NASBO. While some amount of heterogeneity exists across funds, and not all states report their RDF balance separately from their general fund, budget stabilization funds are a useful metric due to their explicit purpose of preparation for adverse shocks. A second, and slightly more expansive, definition includes all end-year balances in a state's general fund; while such a measure will include unplanned revenue and spending shocks, it captures all rainy day fund activity and provides a consistent measure across states.

While the first two potential measures are taken from the NASBO reports, the other two are found in the U.S. Census Bureau's annual Census of Governments dataset. The third potential measure of state government savings is a state's net assets–cash and securities less debt outstanding–not including assets set aside for insurance purposes (pensions, etc.). The fourth measure is all of a state's net assets, including those in insurance-type funds.

My preferred measures of state government savings are measures two and three. These measures, total balances in general funds (including rainy day funds) and net non-insurance assets, provide a nice balance between the ideal features of a savings measurement.

They are consistent across states, relatively general, and include a good deal of long-term savings components. Importantly, however, the qualitative results are not altered by the choice of savings measure.

2.2 Three stylized facts

2.2.1 Fact 1: State savings are positive and procyclical

The first stylized fact I identify is the presence of positive and procyclical savings behavior on the part of state governments. Regardless of which measure of savings measure is observed, U.S. states mostly run positive balances. This is not in itself a surprising result; in fact, it is exactly what one might expect given the balanced budget requirement imposed on 49 of the 50 U.S. states.[5] Table 1 presents summary statistics for the savings measures of interest, both as a fraction of gross state product and as a fraction of general current state government expenditures. Clearly, states run positive levels of savings–0.5 percent or 4.3 percent, depending on the definition–on average, although some observations do record negative savings levels.

In addition to being overwhelmingly positive, state government savings also move with the business cycle. Figures 1, 2, 3, and 4 show how various percentiles of the distribution of savings across states move over the business cycle for the four measures of state savings, where the shaded regions indicate NBER recession dates. Clearly, savings balances build up in economic expansions and spend down in recessions; this is consistent with the stated

[5]NCSL, 2010.

Table 1: Measures of state government savings: summary statistics

Savings measure	Mean	Variance	Percentiles		
			50th	10th	90th
BSF over GSP	0.0038	0.0003	0.0012	0	0.0040
Gen. fund balance over GSP	0.0051	0.0003	0.0026	0.0002	0.0083
Net noninsurance assets over GSP	0.0427	0.0139	0.0175	-0.0258	0.1060
Net total assets over GSP	0.1763	0.0208	0.1600	0.0594	0.2823
BSF over expenditures	0.0228	0.0066	0.0102	0	0.0371
Gen. fund balance over expenditures	0.0379	0.0063	0.0242	0.0013	0.0776
Net noninsurance assets over expenditures	0.3367	0.5174	0.1604	-0.2329	0.9355
Net total assets over expenditures	1.5531	0.7419	1.4838	0.6304	2.4441

Note: Moments reported here are over all state-year observations. Data on budget stabilization funds and general fund balance come from the NASBO fiscal survey of the states, data on net assets come from the Census of Governments, and gross state products are obtained from UKCPR. Sample periods are as follows: BSFs from 1985-2016, balances from 1979-2016, both net assets series from 1981-2012.

purpose of RDFs, which are included in these measures. I interpret this behavior as being indicative of a precautionary savings motive on the part of state governments, induced by the presence of balanced budget rules and the desire of policy makers to smooth expenditures over the cycle.

As a supplemental example, I also plot the series of Kentucky's balances over GSP alongside its HP-filtered log GSP series in Figure 5. The cyclical behavior of Kentucky's balances seems acyclical in the 1980s; however, in the early 1990s they come more into line with what would be expected under a precautionary savings motive, building up in state level expansions and spending down during contractions. Notably, the fund doesn't simply respond to U.S. level decreases in output relative to trend; it experiences a decrease in the mid-1990s and recently in the mid-2010s, both corresponding to downturns in gross state product. Furthermore, note that the mid-2000s recession seems to begin earlier in the state, and the state's balances begin to respond accordingly before the U.S. as a whole fell into recession. Furthermore, over the entire sample the correlation coefficient of the two series is 0.40, further indication of significant precautionary savings behavior in Kentucky.

Figure 1

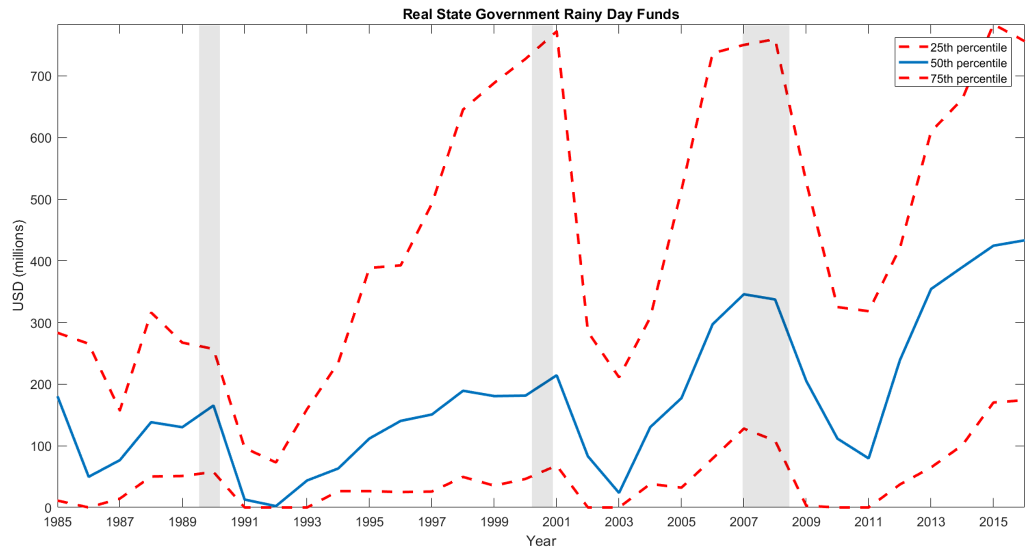


Figure 2

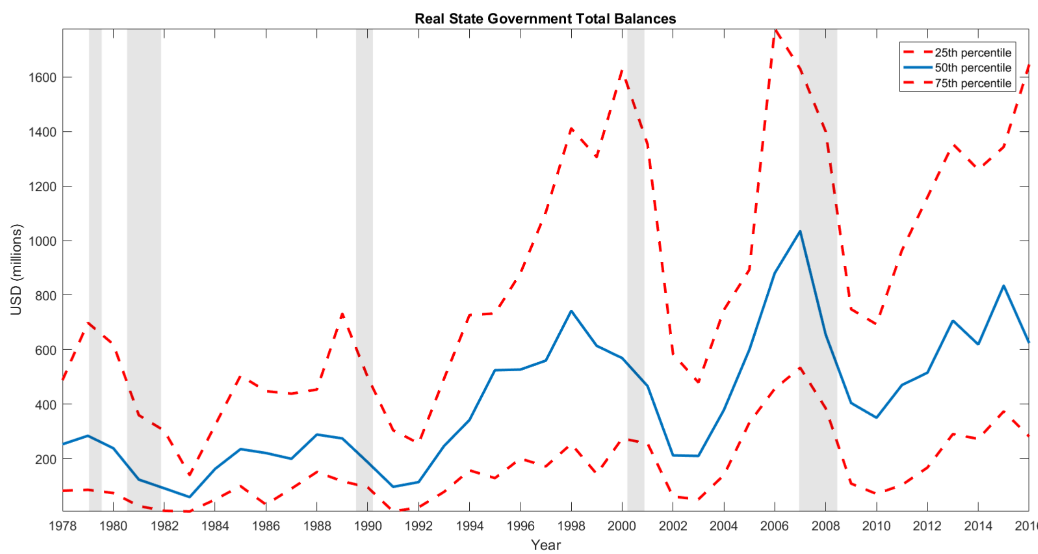


Figure 3

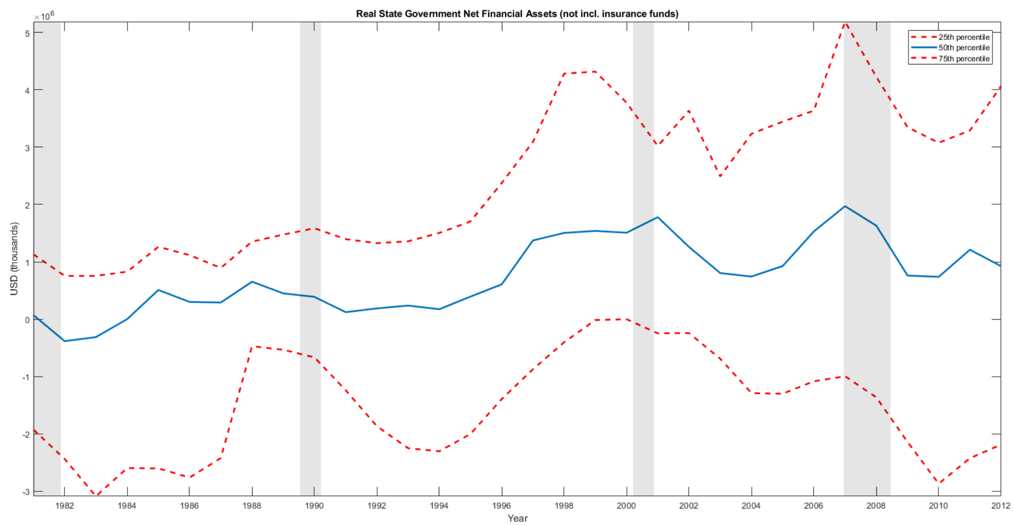


Figure 4

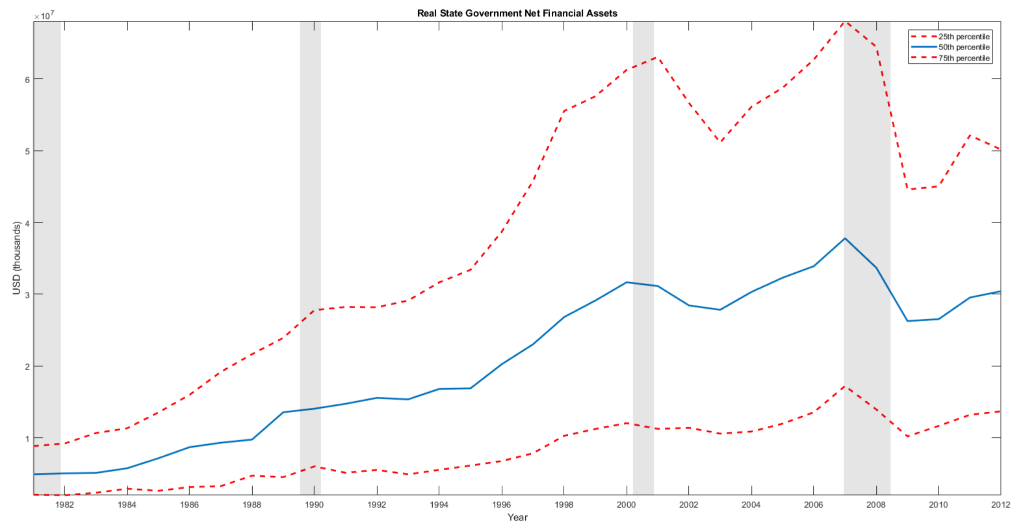
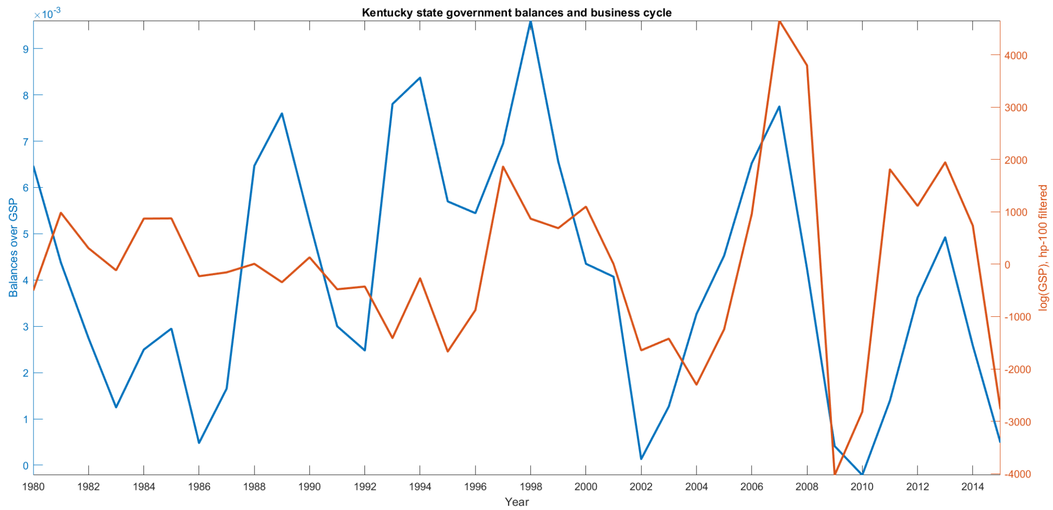


Figure 5



2.2.2 Fact 2: Transfer receipts are countercyclical and respond heavily to national cycle

The second stylized fact describes the behavior of state governments' transfer receipts from the federal government. These transfer payments are countercyclical, as one might expect, but respond quite differently to aggregate and idiosyncratic fluctuations. Specifically, a state government's transfer receipts from the federal government respond more strongly to the condition of the U.S. economy as a whole than to economic conditions within a state. In other words, Michigan might expect an increase in transfers when the rest of the country goes into recession, even if Michigan is expanding; conversely, Michigan may not expect as much revenue from the federal government when it is contracting, if the rest of the country is doing well. This fact runs counter to the idea that fiscal unions serve to smooth idiosyncratic risk across members.

In order to observe the relationship between business cycles and transfers from the federal government to state governments, I estimate the following equation:

$$\log(T_{it}) = 1 + \beta_1 y_{it} + \beta_2 y_{-i,t} + \Gamma X_{it} + \varepsilon_{it}. \tag{1}$$

In this equation, T_{it} represents the amount of transfers state i receives from the federal government in year t. y_{it} and $y_{-i,t}$ represent the cyclical components of state i's output and the sum of the other states' outputs, respectively. X_{it} is a vector of controls, including population and state fixed effects. There is, of course, a potential source of endogeneity in this regression: transfers from the federal government to state government i may have an effect on the local business cycle in state i, biasing the estimate of β_1 toward zero. In Appendix A, I instrument for y_{it} and $y_{-i,t}$ using a measure of monetary shocks, which I argue are plausibly exogeneous to state-level transfers, and show that the main result of this section is not affected; if anything, the difference is more stark.

Table 2 presents the output from a regression of state receipts from the federal government on population, cyclical GSP, and the cyclical component of the sum of the GSP of the other states. The response of federal transfers to a state respond more strongly to the cyclical component of the *aggregate* economy (less GSP of the state itself) than to the *idiosyncratic* cycle of the individual state. A one percent decrease in a state's own GSP relative to trend results in a 0.2 percent increase in transfer receipts; at the same time, a similar decrease in other states' GSP would yield a 0.5 percent increase in the state's receipts.

For a bit more insight into the composition of these transfer receipts, consider Figure

Table 2: Determinants of state government receipts from federal government

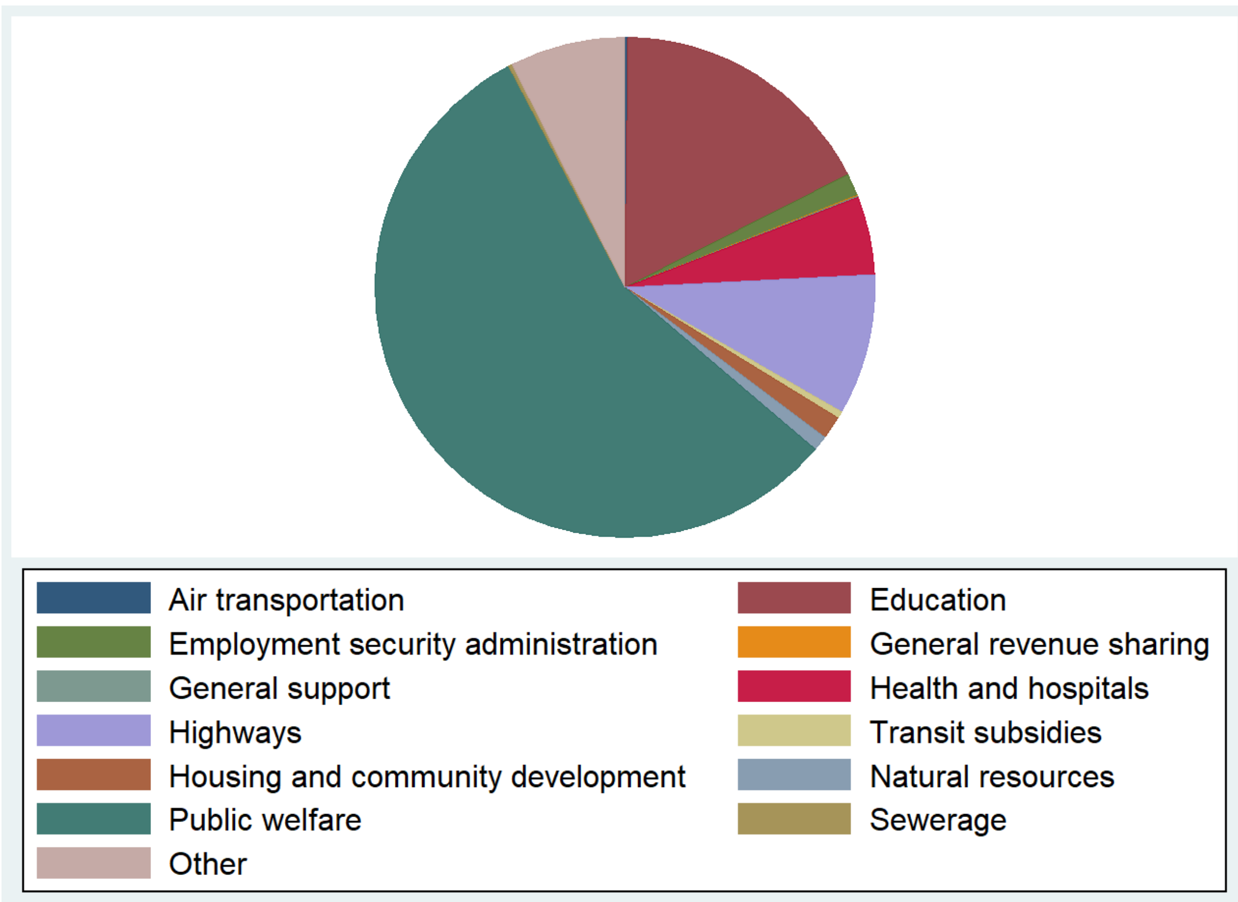
Variable	$\log(pop)$	$\log(GSP_i)$, cyclical	$\log(GSP_{-i})$, cyclical
Coefficient	0.0061	-0.2083**	-0.5068***
(s.e.)	(0.0021)	(0.1016)	(0.1111)

Note: Results from a fixed-effects regression with standard errors clustered at the state level. Observations include 46 states for which holes do not exist in the Census of Governments data from 1981 to 2012. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.

6. Clearly, the most significant component of federal government transfers to states is the 'public welfare' category; this category includes funding for a wide range of public assistance programs that are administered at the state level, Medicaid being the largest among them. the second biggest category is for education funding, and the third for highways. The previous result about the response of federal transfers to the business cycle of the aggregate economy seems to be driven by the two biggest categories, public welfare and education, as both of these transfer categories exhibit the same pattern of greater response to the aggregate business cycle.

That public welfare drives a large part of the main result in this section might raise concern upon a first glance. The public welfare portion mainly consists of Medicaid payments, unemployment insurance, etc.; these transfers are typically formulaic, simply responding to claims made by low income individuals. Thus, it might seem strange to claim, as the model below does, that the result displayed in Table 2 could reflect some information or political friction in the fiscal policy system. However, while the business-as-usual operations of these transfers involve responses to demand, the federal government has shown that it is willing to step in and increase these transfers in a *discretionary* way in response to large business cycle shocks. The most recent example of such an action is in

Figure 6: Composition of federal transfers to states



the American Reinvestment and Recovery Act (ARRA) of early 2009, which was the largest fiscal stimulus response to the Great Recession in the U.S. The ARRA included an increase in Medicaid payments amounting to about \$87 billion dollars to be paid to states[6], over and above what would normally have been paid, for the years 2009 and 2010.

Such a discretionary increase in these payments is exactly in line with the results found in this section; the federal government only responded with large increases in Medicaid transfers when *the whole country* was in recession, rather than in response to idiosyncratic state-level downturns. This only matters, of course, if state-level business cycles are substantially different from the aggregate business cycle. I argue here that state-level recessions are indeed quite distinct from the aggregate business cycle, and occur with greater frequency.

To identify state-level recessions, I follow Brown (2017) by using the Philadelphia Fed's monthly coincident indices, which are available both for states and for the U.S. as a whole. I identify the turning points of the cyclical component of this index using the modified BBQ (MBBQ) algorithm from Engel[7], and identify recessions for the U.S. and all fifty states therein. While only 4 recessions are identified for the U.S. over the sample period (1979-2017), most states experienced more than four recessions; furthermore, states were in recession for an average of 73 months, compared to just 46 months for the U.S. nationally. These recession differences suggest that U.S. states experience heterogeneous idiosyncratic shocks apart from the U.S. business cycle as a whole.

That states' business cycles differ substantially from the U.S. business cycle sug-

[6]https://www.healthaffairs.org/do/10.1377/hpb20100715.109669/full/

[7]Engel modifies the BBQ algorithm of Harding and Pagan (2002), and provides code at http://www.ncer.edu.au/data.

gests the transfer responses identified here will have significant implications for risk in state government budgets. Notably, a state whose business cycle moves more independently from the rest of the country might be exposed to more risk because of the federal transfer system than an otherwise equal state whose cycle moved more instep with the U.S. cycle. Having already identified possible precautionary savings behavior by state governments, one might expect these independent states' governments to save more relative to other states; indeed, that is what these policy makers do, as I show in the following section.

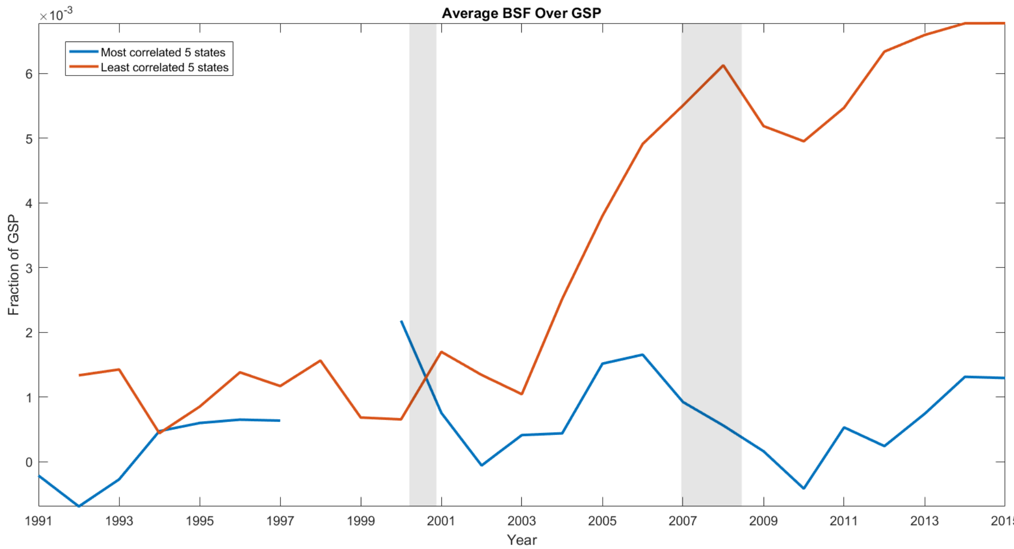
2.2.3 Fact 3: Less correlated states save more

If the transfer policy of the U.S. federal government to U.S. state governments doesn't respond as much to idiosyncratic fluctuations, then states whose cycles are less correlated with the rest of the country might be expected to run higher balances of government savings. To evaluate this prediction, I develop a measure of a state's correlation with the business cycle of the rest of the country. For each state, I apply an HP-100 filter to two annual time series: the state's annual real GSP series and real U.S. GDP less the state's GSP. The long-run correlation of the cyclical component of each of these time series yields the correlation of a state's business cycle with that of the other 49 states. In this section, I show that this 'correlation' measure is negatively associated with precautionary savings behavior on the part of U.S. state governments.

Figures 7, 8, 9, and 10 show the time path of state government savings for the five most correlated and least correlated U.S. states with GDP.[8] Clearly, states whose business

[8]For the remainder of the paper, I disregard Alaska. Alaska's reserve funds are massive in comparison to

Figure 7



cycles are least correlated with the U.S. business cycle run higher levels of government savings as a percentage of GSP than those which are most correlated. The most stark example is Figure 9, in which the most correlated states on average run slightly negative net assets (not including insurance funds). For a flavor of how correlations vary across the U.S., see Figure 11, in which states whose cyclical GSP is more correlated with U.S. GDP are highlighted.

Of course, there are a multitude of factors determining how correlated a state is with the rest of the country, some of which may also affect a state government's level of savings. To further demonstrate the relationship between the correlation measure and a state's government savings, I estimate the equation

$$s_{it} = 1 + \beta_1 y_{it} + \beta_2 y_{it}^{cycle} + \beta_3 \rho_i + \beta_4 \rho_i y_{it}^{cycle} + \Gamma X_{it} + \varepsilon_{it}. \tag{2}$$

the other states, and it is the least correlated with the rest of the U.S. The case of Alaska certainly supports my conclusions, but I want to prevent it from driving the results entirely.

Figure 8

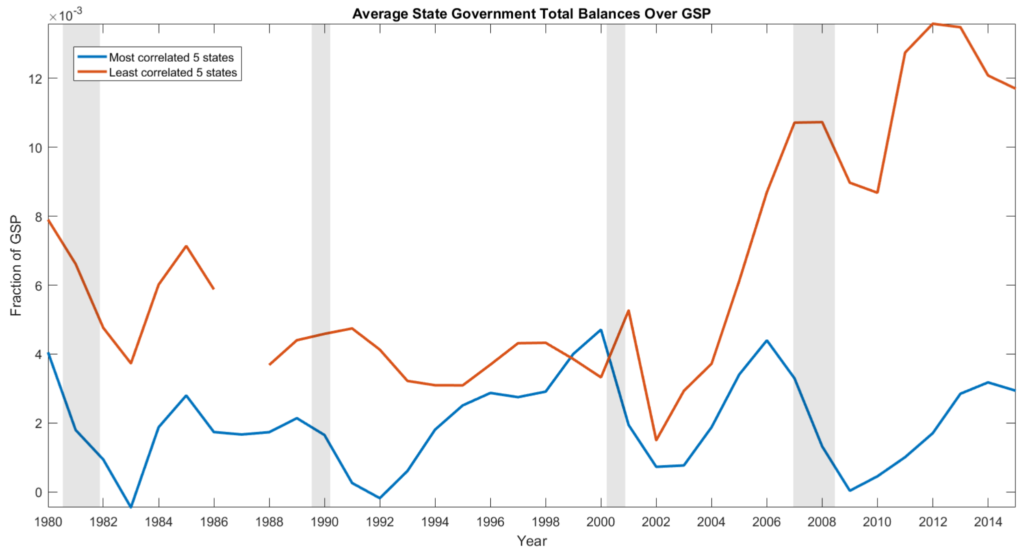


Figure 9

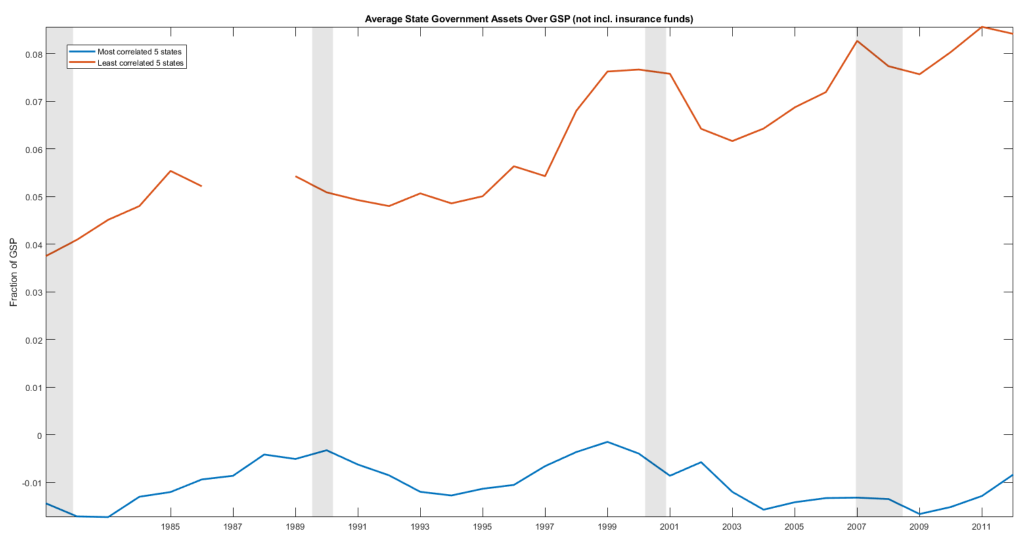


Figure 10

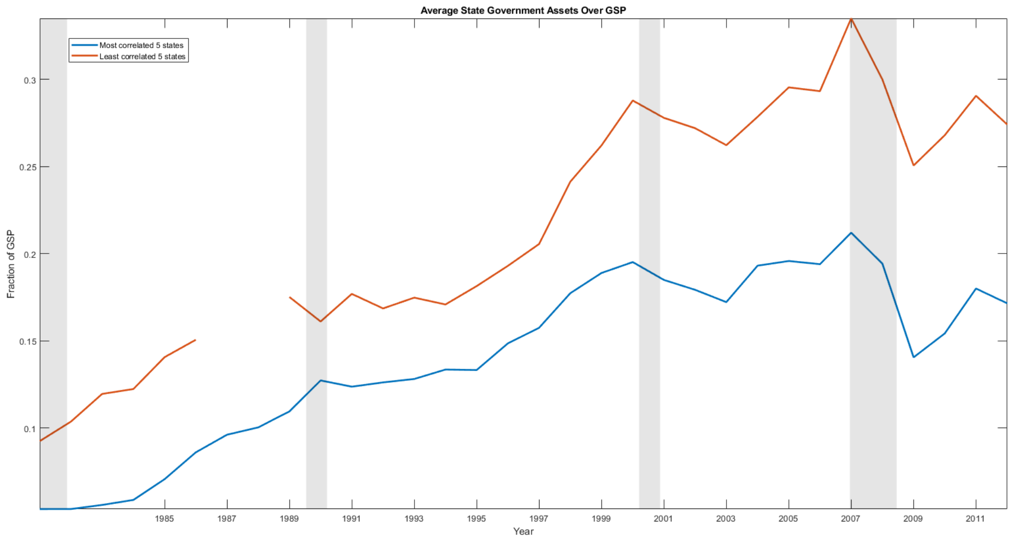
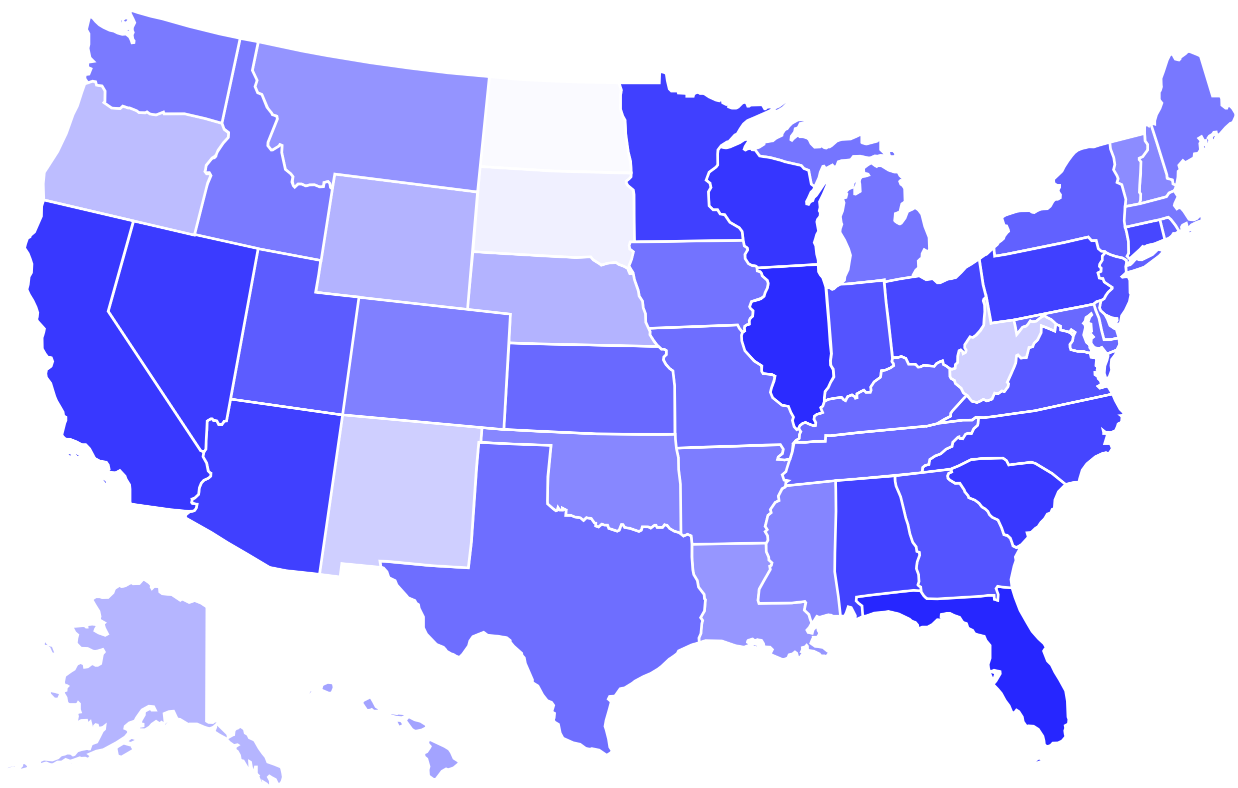


Figure 11: State correlations with the national business cycle



Note: More blue = higher correlation of a state's business cycle with the U.S. business cycle.

Table 3: Determinants of State Government Balances

Dependent variable	log(∼ Real balances)			Real balances / GSP			Real balances / Expenditures		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Business cycle correlation	-0.0920**	-0.0825*	-0.0847*	-0.0054***	-0.0038**	-0.0038**	-0.0412***	-0.0262**	-0.0262**
	(0.0412)	(0.0466)	(0.0468)	(0.0016)	(0.0015)	(0.0015)	(0.0144)	(0.0128)	(0.0127)
Log(GSP), cyclical	0.5505***	0.4131**	0.1138	0.0225***	0.0177***	0.0167***	0.3036***	0.2536***	0.2487***
	(0.1886)	(0.1885)	(0.0789)	(0.0042)	(0.0050)	(0.0063)	(0.0377)	(0.0454)	(0.0547)
Log(GSP), cyclical * High correlation	-	-	0.9854*	-	-	0.0031	-	-	0.0155
			(0.5528)			(0.0068)			(0.0652)
Log(GSP)	0.0537***	0.0570***	0.0577***	-	-	-	-	-	-
	(0.0124)	(0.0131)	(0.0132)						
Controls	N	Y	Y	N	Y	Y	N	Y	Y

Note: The sample for these regressions is 49 U.S. states (Alaska not included) for the years 1981-2012. The regressions are according to a random effects model. Standard errors are clustered at the state level. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 4: Determinants of State Government Net Assets (not incl. insurance funds)

Dependent variable	log(∼ Real net assets)			Real net assets / GSP			Real net assets / Expenditures		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Business cycle correlation	-1.2630***	-1.2365***	-1.2320***	-0.1168***	-0.0605**	-0.0607**	-1.0787***	-0.5528***	-0.5541***
	(0.3325)	(0.3857)	(0.3845)	(0.0393)	(0.0267)	(0.0267)	(0.3393)	(0.2115)	(0.2118)
Log(GSP), cyclical	0.9278**	0.5754	0.0538	0.0513*	0.0581*	0.0202	0.9424***	1.0980***	0.9055***
	(0.3416)	(0.6129)	(0.6406)	(0.0274)	(0.0328)	(0.0381)	(0.1349)	(0.1655)	(0.2011)
Log(GSP), cyclical * High correlation	-	-	1.8011**	-	-	0.1196***	-	-	0.6059**
			(0.7729)			(0.0413)			(0.2714)
Log(GSP)	0.1993**	0.3001***	0.2979***	-	-	-	-	-	-
	(0.0834)	(0.0857)	(0.0852)						
Controls	N	Y	Y	N	Y	Y	N	Y	Y

Note: The sample for these regressions is 49 U.S. states (Alaska not included) for the years 1981-2012. The regressions are according to a random effects model. Standard errors are clustered at the state level. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Here s_{it} is some measure of state government savings, y_{it} is gross state product, y_{it}^{cycle} is its cyclical component, and ρ_i is the main explanatory variable of interest, namely, a state's correlation with the business cycle of the rest of the country. Because ρ_i is a time-invariant object at the state level, I estimate a random-effects model[9] and cluster standard errors at the state level. Tables 9 and 10 give the output from a selection of these regressions for the two preferred definitions of state government savings.

Clearly, the relationship between 'correlation' and state government savings is negative and significant in all specifications of the estimation model. The interpretation is exactly the stylized fact highlighted in this section: states whose business cycles are less correlated with the rest of the U.S. run higher levels of government savings. Evidence of

[9] Wooldridge, 2010.

the procyclicality of these savings balances is also seen in most specifications. Qualitatively, these results are robust to any of the aforementioned measures of state government savings.[10]

Among the controls, the variance of a state's cyclical GSP is sometimes positively related with savings levels, lending more evidence to the idea that these savings measures capture precautionary savings behavior.[11] There may also be weak evidence that the less correlated governments are more hesitant to spend out of their savings in bad times, perhaps out of desire to have funds in case worse conditions hit later. Regarding other control variables of interest, states with Democrat governors tend to run lower levels of savings, and the strength of a state's balanced budget rule seems not to be associated with higher savings levels. I include a fuller version of some of these regressions in Appendix B.

When combined with stylized facts 1 and 2, this third fact hints at an important feature of the effect of the federalist structure of the U.S. on state-level fiscal policy. It seems that, by exposing less correlated state governments to more risk by not insuring them against downturns as much as the more correlated states, the federal government creates stronger incentives for these state governments to engage in precautionary savings behavior. The rest of the paper attempts to expand on this story by putting forth a quantitative model of federalism and government policy over the business cycle that are able to reproduce these facts and others related to public finance over the business cycle. The model will allow counterfactual analysis of policies like balanced budget rules at the state level, shed light on the broader debate about the role for states in pursuing countercyclical fiscal policy, and

[10] The stylized fact also remains when the regressions are weighted by GSP.

[11] Seegert (2017) documents the rise in volatility of state tax revenues over time; this may also explain some of the rise in the savings measure over time for many states.

contribute to the discussions aboutfiscal unionization. For example, counter to Oates (1972), if real frictions to centralized fiscal policy are sizeable enough, it may be optimal for lower levels of government to engage in stimulus policy.

3 An information model

To begin thinking about the cyclical behavior of state government savings in a quantitative sense, I put forward a model of multi-tiered governments and imformation asymmetries. The basic structure of the model is as follows: a state is modeled as a small endowment economy in a fiscal federation, or a 'region,' to avoid confusing usage of the word 'state.' There are two levels of benevolent governments, regional and central. The regional government must provide a certain level of some public good, but is subject to strict borrowing limits. The central government is not subject to borrowing restrictions and makes tax and transfer policy to help regional governments smooth consumption, but only observes the state of the world with a noisy signal.

The balanced budget restriction at the regional level versus the information friction at the central level is the key trade-off in the allocation of fiscal policy. In a model without frictions, there would be no difference between the provision of financing for the public good at the local or central level, as either government would be able to perfectly smooth the representative household's consumption over the cycle. Furthermore, in the presence of any sort of balanced budget requirement or a similar disadvantage in smoothing consumption at the local level, it would be optimal for the central government to take over all countercyclical fiscal policy, leaving the local government to simply levy a tax exactly equal to public goods spending.[12] This is one conventional wisdom on federalism and fiscal policy articulated in Oates (1972).

Such specialization in fiscal policy is not observed in the data, however. As noted above, U.S. states engage in precautionary savings behavior. Therefore, it is likely not the case that centralized fiscal policy is strictly preferred to decentralized policy; there must be some trade-off between policies at regional and central levels. I propose to model this trade-off by way of an information friction on the part of the central government. While the central government has an advantage in its ability to smooth consumption through borrowing and/or compulsory transfers, it does not observe the state of the economy exactly, receiving a noisy signal about the endowment shock. Because of this, the central government will not respond perfectly to region-specific shocks, requiring the regional government to save up funds in order to smooth.

This way of motivating the trade-off is consistent with discussions about the advantages of state and local governments *vis-a-vis* central governments. For example, the CBO references differences in information about citizens' situations and preferences as a reason why local government action might be preferred in some cases.[13] The 'signal' method of modeling an information friction provided here can be interpreted in a number of ways. The most obvious interpretation is that of a central fiscal authority having imperfect measurement of indicators the regional economy; however, it could also be that a far-away central

[12] Goodspeed (2016) studies the trade-off between federal transfers and rainy-day funds, where the relative effectiveness of each government's fiscal policies may differ structurally. In this case, the central government may not want to fully take over.

[13] CBO, 2013.

authority, although receiving accurate measurements, is not as 'tuned in' as local authorities with the effects on local citizens of the observed shocks. Furthermore, an even more reduced form interpretation of the information friction is that it captures other factors which might dampen the ability of a central fiscal authority to respond to local shocks, including political economy frictions like slow or biased legislatures. The idea that local governments have better ability to know and match the preferences of their constituents goes all the way back to Tiebout (1956), and the political economy friction imposed by a legislature in centralized provision is found most notably in (Besley and Coate, 2003).

3.1 Model environment

3.1.1 Endowment process

Income for the household in region i is allocated exogenously according to an endowment process. The household is passive; it does not engage in any behavior to affect its consumption.[14] The endowment in period t for region i is given by the following:

$$y_{it} = \bar{y} + \gamma z_{it} + \epsilon_{it}, \tag{3}$$

where $\bar{y}$ is the long-run mean of income, z_{it} is an aggregate component, ϵ_{it} is an idiosyncratic component, and γ multiplies the aggregate component. Both components follow an AR(1)

[14] The household may be thought to engage in one action, namely, the election of a regional government. In the framework here of a representative household, a government whose preferences exactly align with the household's is elected; this is exactly the type of regional government I consider. Equating the household and government's preferences and decisions for consumption and savings is a strategy used in Aguiar and Amador (2011).

process, for example, the process for ϵ_{it} is given by

$$\epsilon_{it} = \rho_\epsilon \epsilon_{i,t-1} + \xi^\epsilon_{it}, \tag{4}$$

where $\xi^\epsilon \sim N(0, \sigma^2_\epsilon)$.

Note that regions here are modeled as a continuum of *ex-ante* identical islands. The lack of ability to trade with other regions is an extreme assumption, but it highlights the lack of complete insurance available to the regional agents. It also eliminates the complications that might be introduced by regional governments competing strategically with one another. While inter-region games are no doubt interesting, the strategic interactions of interest in this paper are those between the central government and the subnational governments.

3.1.2 Regional government

The problem of the government in region i is to choose a stream of taxes and savings, τ_{it} and s_{it}, to finance an exogenous stream of government purchases g_{it}, which generate no utility. The preferences of the government are exactly aligned with those of the representative household, which has utility over consumption in every period:

$$W\big(\{c_t\}_{t=0}^{\infty}\big) = \mathbb{E}\Big[\sum_{t=0}^{\infty} \beta^t U(c_{it})\Big]. \tag{5}$$

The government is subject to the following constraints:

$$c_{it} = y_{it} - \tau_{it}$$

$$g_{it} + s_{it} = \tau_{it} + T_{it} + (1+r)s_{i,t-1}$$

$$s_{it} \geq \phi,$$

where τ_{it} is the lump sump tax chosen in period t, s_{it} is the savings (negative debt) of the regional government, y_{it} is the endowment, g_{it} is required government spending, ϕ is the per-period borrowing constraint, and T_{it} is the fiscal transfer from the federal government, which will be taken as given from the perspective of the regional government.

The transfers will result from the policy function of the central government, $T(s_t, z_t, \theta_t, f_t)$, where θ is a noisy signal of ϵ_t which is unobserved by the regional government, and f_t is its prior belief about ϵ_t; both of these will be explained shortly. Given the observed state variables, the regional government cannot predict transfers T exactly, and must choose its policy to maximize *expected* utility over the possible realizations of the transfer function, such that its dynamic programming problem can be described by the following equation:

$$\begin{aligned} V^R(s_t, z_t, \epsilon_t) &= \max_{s_{t+1} \geq \phi} \mathbb{E}_t[c_t] + \beta \mathbb{E}_t\big[V^R(s_{t+1}, z_{t+1}, \epsilon_{t+1})\big] \\ \texttt{s.t. } c_t + s_{t+1} &= y_t + T(s_t, z_t, \theta_t, f_t) + (1+r)s_t - g_t. \end{aligned} \tag{6}$$

Note the presence in this problem of an expectation operator on current period consumption; in this model, the local government chooses next period savings before observing the realization of transfers T from the central government, and must use taxes and subsidies to balance the budget at the end of the period.

3.1.3 Central government

In addition to the regional government, the central government features as a second optimizing agent in the model. Its inclusion reflects the fact that, in the context of the U.S., the federal government is not a passive agent with regard to fiscal policy. While much federal spending, such as the Social Security program, is indeed formulaic, the federal government also engages in a large amount of discretionary spending, up to a third of which is a direct transfer to the states. The central government is benevolent, so its optimization problem at first glance is almost equivalent to that of the regional government:

$$\begin{aligned} V^C(s_t, z_t, \theta_t, f_t) &= \max_{T_t} \mathbb{E}_t[c_t] + \beta \mathbb{E}_t\big[V^C(s_{t+1}, z_{t+1}, \theta_{t+1}, f_{t+1})\big] \\ \texttt{s.t. } c_t + s(s_t, z_t, \epsilon_t) &= y_t + T_t + (1+r)s_t - g_t. \end{aligned} \tag{7}$$

Note, however, that the differences between the two decision problems are not inconsequential; the model generates a wedge between the decision rules even in the presence of identical welfare functions.[15] First, the central government's choice variable is T_t rather than s_t. While the fiscal balance carried over into the next period is chosen by the regional governments, the

[15]This paper abstracts from the possibility that the regional government could simply tell the central government what its state is. The information friction might be thought of as the noise introduced as information is passed from lower levels of government to higher levels. Of course, differences in objective functions would exacerbate the differences in behavior, but the information mechanism alone is of sufficient interest for the purposes of this paper.

central government chooses how much to give to (or take from) the regional governments in the form of transfers in each period. Furthermore, there is no period budget balance necessarily required on the part of the central government. I assume that the central government can perfectly observe the aggregate shock z_t; as a result, it is able to perfectly insure the regions against aggregate shocks. Therefore, for the remainder of the paper I abstract from the aggregate shocks, and consider a model with only idiosyncratic shocks and the recasted policy functions $s(s_t, \epsilon_t, f_t)$ and $T(s_t, \theta_t, f_t)$. Given this recasting, two mechanisms can be employed to discipline the financial behavior of the central government and prevent it from accumulating debt indefinitely.

The first mechanism that can be employed is budget balance over the infinite horizon, i.e., a no-Ponzi-game condition on the central government's assets. In this framework, there is a finite number of regions, and the central government has a stock of assets out of which positive transfers are paid and into which negative transfers are deposited. The no-Ponzi-game condition, then, is given by

$$\lim_{t\to\infty} \mathbb{E}_0\Big[\frac{A_t}{(1+r)^t} = 0\Big], \tag{8}$$

where A_t is the stock of assets held by the central government for the purposes of transfers to the regional government.

The second method is to have period budget balance and an infinite number of regional governments. In this setup, the central government in every period takes from some regions and gives to others, such that total transfers (for idiosyncratic shocks) net out to zero:

$$\int T_{it} di = 0. \tag{9}$$

For the simple case in which all regions are identical, solving for the transfer function in this case is analytically equivalent to the solution for the first mechanism. Appendix C shows that both mechanisms result in the simple budget condition $\mathbb{E}_0\big[T(s_t, \theta_t, f_t)\big] = 0$.

In addition to the differences in choice variables, note that the state variables are also different for the central government. The central government observes s_t, but receives a noisy signal θ_t about the state variable ϵ_t:

$$\begin{gathered} \theta_t = \epsilon_t + \xi_t^\theta \\ \xi_t^\theta \sim N(0, \sigma^2_{\xi^\theta}). \end{gathered} \tag{10}$$

Here, ξ_t^θ is the noise component of the signal, and σ_{ξ^θ} reflects the relative noisiness of the signal. Finally, the central government brings into the period a prior belief on the distribution of the idiosyncratic component ϵ: $f_t = N(\mu_t, \sigma^2_{\mu,t})$. After observing the signal, the central government updates this prior to form a posterior with which it forms its expectation for the choice of transfer, then projects this posterior forward into the next period using the law of motion for ϵ. This process is described in further detail in the next section.

3.2 Bayesian updating

The central government begins time period t with a prior belief f_t on the distribution of ϵ_t: $f_t = N(\mu_t, \sigma^2_{\mu,t})$. Upon observing the noisy signal θ_t, the central government updates its belief to $\hat{f}_t = N(\hat{\mu}_t, \hat{\sigma}^2_{\mu,t})$ according to the following rules, which mimic the classic signal extraction problem put forth in Lucas (1973):

$$\hat{\mu}_t = \mu_t + \frac{\sigma^2_{\mu,t}}{\sigma^2_{\mu,t} + \sigma^2_{\xi^\theta}}(\theta_t - \mu_t) \tag{11}$$

$$\hat{\sigma}^2_{\mu,t} = \frac{\sigma^2_{\mu,t}\sigma^2_{\xi^\theta}}{\sigma^2_{\mu,t} + \sigma^2_{\xi^\theta}}. \tag{12}$$

It is this distribution $\hat{f}_t$ that the central government uses to form its expectations when solving for its optimal policy. The extent to which the belief about the mean is updated after observing the signal is determined by the relative variance of the noisy portion of the signal. The noisier the signal, the less weight is attached to it in the process of forming beliefs about the region's endowment.

At the end of the period, the central government must form its belief about ϵ_{t+1}, which is the prior distribution it will bring into the next period as a state variable. These priors for period $t+1$ are formed from applying the known $AR(1)$ process to the posteriors formed in period t:

$$\mu_{t+1} = \rho_\epsilon \hat{\mu}_t \tag{13}$$

$$\sigma^2_{\mu,t+1} = \rho^2_\epsilon \hat{\sigma}^2_{\mu,t} + \sigma^2_{\xi^\epsilon}. \tag{14}$$

Given these laws of motion, the posterior variance $\hat{\sigma}^2_{\mu,t}$ is bounded in the long run, and under certain conditions converges to a single value. In Appendix D, I show that the fixed point is

$$\hat{\sigma}^2_{\mu,\infty} = \frac{(\rho^2_\epsilon - 1)\sigma^2_{\xi^\theta} + \sigma^2_{\xi^\epsilon} + \sqrt{\left[(\rho^2_\epsilon - 1)\sigma^2_{\xi^\theta} + \sigma^2_{\xi^\epsilon}\right]^2 + 4\rho^2_\epsilon \sigma^2_{\xi^\theta}\sigma^2_{\xi^\epsilon}}}{2\rho^2_\epsilon}. \tag{15}$$

In solving the model, I assume that the central government has already reached this value for the posterior variance. This eliminates another state variable and allows the belief about the distribution of ϵ to be characterized by movements in μ_t.

3.3 Timing and Equilibrium

The timing of events in the model is as follows. In every period t,

1. All shocks ξ are realized.
2. Regional governments observe the true shock to their endowment ξ_ϵ, but not the private signal θ_t. The central governments observes the noisy signal θ_t.
3. The central government forms its update belief $\hat{f}_t$ from the prior belief f and the signal θ_t.
4. Transfers and next period savings are chosen and committed to simultaneously by the central government and regional governments, respectively.

5. Regional taxes adjust to satisfy the choice of s_{t+1}, given the realization of T_t.

6. The central government uses $\hat{f}_t$ to form f_{t+1}, the prior belief going into the next period.

Definition: *A Markov Perfect Equilibrium is a set of policy functions* $\{s(s_t, \epsilon_t, f_t), T(s_t, \theta_t, f_t)\}$ *such that, given exogenous processes for* ϵ_t*,* θ_t*, and* g_t*,*

1. $s(s_t, \epsilon_t, f_t)$ *solves the regional government's problem given* $T(s_t, \theta_t, f_t)$*, and*

2. $T(s_t, \theta_t, f_t)$ *solves the central government's problem given* $s(s_t, \epsilon_t, f_t)$*.*

Here I define the equilibrium with one region, but in principle there could be many of these regions, each with its own equilibrium with respect to the central government. Since these regional governments are islands in the model, the solutions are separable, and it is helpful to cast the problem in terms of one region only.

Note that the simultaneity is an important assumption in the model. If, upon realization of shocks, one government moved first, then its move would reveal what its information was. A sequential game, therefore, would include signaling elements into the strategic decision-making process. While signaling may be an important factor in reality, whether the local or federal government is the more realistic first mover within a period is unclear. Additionally, given that, in the real world, policy-making is a continuously ongoing process, the simultaneity assumption is not particularly incredible.

3.4 Relation to a political economy model

Thus far, I have specified the main friction to central government policy making as a matter of imperfect information and learning on the part of the central government. The other compelling source of inefficiency in centralized policy is political in nature. Discretionary transfers to regions/states and their agencies originate from budgetary decisions made in a legislative body; while noisy signals are likely at play here, political processes and voting are a major determinant of transfers. The federal government may not respond to idiosyncratic shocks simply because others vote down extra transfers to places in recession.

While the political story is somewhat different, I propose that the information frictions modeled above can be thought of as including political frictions, as well. To see this, consider a simplified version of the information model, in which there is no persistence for the idiosyncratic component ($\rho_\epsilon = 0$) for simplicity. Suppose the noise shock ξ^θ can take on one of two values: $\xi^\theta \in [-\bar{\xi^\theta}, \bar{\xi^\theta}]$, each with probability 1/2, where $\bar{\xi^\theta} > 0$. From the perspective of the regional government, which knows the true ϵ as well as the transfer function $T(s, \theta)$, it could receive one of two values for the transfer. If $\xi^\theta = -\bar{\xi^\theta}$, transfer T will be higher than it would be in a frictionless model, and vice versa if $\xi^\theta = \bar{\xi^\theta}$. So the regional government forms its expectations and policy knowing that, given s and ϵ, its transfer will be either T_{high} or T_{low}, each with probability 1/2.

Now consider a slightly different model, in which the friction to centralized policy making is political, i.e., transfers are voted on by a legislature for the central government. Following the political economy setup of Besley and Coate (2003), suppose there are two regions in the fiscal federation, and utility spillovers of the following type:

$$U_i(c_i, c_{-i}) = (1-\kappa)u(c_i) + \kappa u(c_{-i}), \kappa \in (0, 1/2).$$

Transfers are chosen by the legislature, which is modeled using the *minimum winning coalition* strategy. In every period, each region has probability 1/2 of being 'in power,' i.e., casting the median vote on transfer policy. If a region ends up in power, it receives a higher-than-efficient transfer, T_{high}, and if it is the minority, it receives a lower-than-efficient transfer T_{low}.[16] So, just as in the simple model of information, this framework requires the regional government to set policy knowing that it will receive T_{high} or T_{low} with probability 1/2, and we can expect its behavior to be similar to that in the simple information model. Given that a well known and widely used model of political frictions can be mapped into a similar version of the information model presented here, I think it reasonable to think of the 'information' friction as potentially including political factors, as well.

4 Quantitative analysis

4.1 Estimation and calibration

In order to examine the properties of the model, it is sufficient to consider the case of a single region. There are no interactions in this model across sectors, and the interactions

[16]Here, as in Besley and Coate's model, the spillover term κ ensures that the deciding voter does not completely disregard the utility of the other region.

Table 5: Baseline parameters, information model

ρ_ϵ	ξ^ϵ	ξ^θ	$\bar{y}$	g	ν	ϕ	β	r
0.5095	0.0280	0.0671	1	0.05	2	0	0.961	0.04

of interest are between the regional governments and the central government. Given this strategy, I attempt to get some results roughly corresponding to the 'median' U.S. state. I estimate an AR(1) model for HP-100 filtered $\log(GSP)$ in all 50 states, and set ρ_ϵ and σ_ϵ to be the respective medians of the AR(1) parameter estimates. I then calibrate σ_{ξ^θ} to match the median of $corr(T_t, y_t)$, the correlation of transfer receipts from the federal government with output, at the state level.

Parameters for the baseline case are given in Table 5. I normalize $\bar{y} = 1$ and set $g_t = g = 0.05$ to roughly approximate data on U.S. state government spending. Utility is CRRA: $u(c) = \frac{c^{1-\nu}-1}{1-\nu}$, and I let $\nu = 2$. I choose an annual interest rate of 0.04, and set the discount rate such that $\beta < \frac{1}{1+r}$ to keep the region from wanting to increase savings indefinitely.[17] I set $\phi = 0$ to reflect the balanced budget constraints that are present in most U.S. states, and choose a realistic upper bound for regional government savings of 0.2, which is not binding in the baseline case. Later, I study the potential welfare effects of lowering ϕ, but 0 is an intuitive choice for the baseline case. I also restrict the transfer policy to respond linearly to the central government's signal, given its prior beliefs. This does not alter its optimal policy much, but it greatly eases the computation burden involved in solving the problem.

I solve for the equilibrium policy functions by the use of an 'inner loop, outer loop'

[17] Aiyagari, 1994.

Table 6: Business cycle moments

	Model	Data (median of log hp-100 filter at state level)
$corr(y_t, T_t)$	-0.1457	-0.1536
$corr(y_t, s_t)$	0.2674	0.2862
$corr(y_t, y_{t-1})$	0.5205	0.5430
$corr(T_t, T_{t-1})$	0.1670	0.3531
$corr(s_t, s_{t-1})$	0.9466	0.1072
$sd(y_t)$	0.0366	0.0281
$sd(T_t)$	0.0170	0.0694
$sd(s_t)$	0.0549	1.16

Note: moments reported here are for the cyclical components of each of these variables.

strategy. The 'inner loop' refers to the process of solving for each policy function given the policy function of the other government. The regional government policy is solved by value function iteration, and the central government policy is a static optimization problem, since its choices do not affect its future value function. The 'outer loop,' then, repeats this process, updating each policy function until both have converged.

4.2 Results

To assess the performance of the model compared to U.S. data, I simulate the calibrated baseline region for 10000 periods and observe its behavior. Table 6 presents some basic moments for some of the key variables of interest. Of the moments which are not explicitly targeted, $corr(y_t, s_t)$, the co-movement of local government savings and output matches remarkably well. The autocorrelation of transfer receipts is a bit low, but in an acceptable qualitative range. The variability of savings and transfers are low relative to the data, but their relative magnitudes to each other seem to make sense.

The one outlier, of course, is the behavior of savings. In the model, savings is more persistent and less variable than it is in the data. One reason for this may be the following: the moments I report in the data are in the extreme long-run case of a static economy. Savings here doesn't grow over time: once it reaches a desired level, it stays there and simply fluctuates around that level. It may be that, in the real world, U.S. states have not yet 'settled' into their desired long-run levels of savings, thus exhibiting more unpredictability.

I also compute the impulse response functions of savings and transfers to idiosyncratic shocks. Figures 12 and 13 give the predictions from the model, while Figures 14 and 15 display results from the data. The IRFs from the data are computed from running a VAR with savings (or transfer), state GSP, and U.S. GDP for all 50 states; I plot the median of the estimated IRFs and the median of the confidence bands. The model predicts a hump-shaped response of savings to an idiosyncratic regional shock, and the data seems to present some weak evidence in favor of this prediction. The complete lack of response of transfers to the regional shock is also consistent with the model, which predicts a response that is stunningly low in magnitude.

The lack of much meaningful transfer response in the model is consistent with the data, and is driven by the massive information cost implied by the baseline calibration. To generate a realistically low correlation between local fluctuations and transfer receipts from the federal government, the variability of the noise component of the central government's signal has to be almost *three times as large* as that of the real idiosyncratic shock. Even though such a sizeable noise shock is necessary to match the data relatively well, information

Figure 12

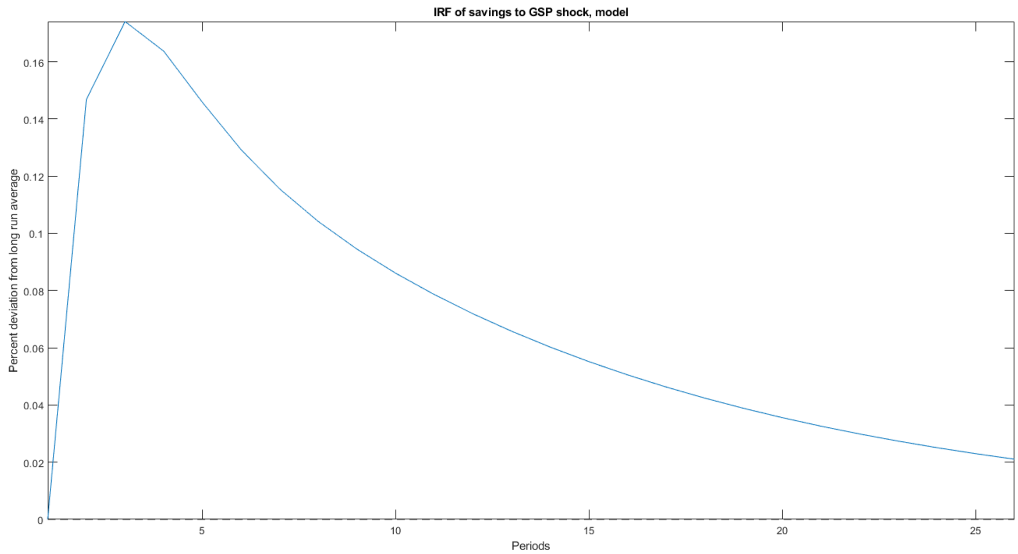


Figure 13

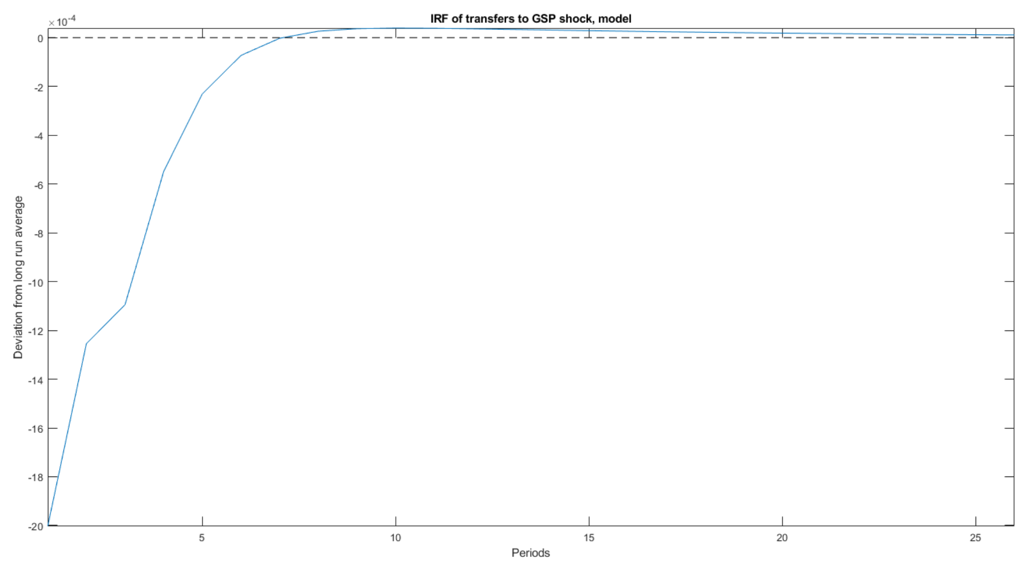


Figure 14

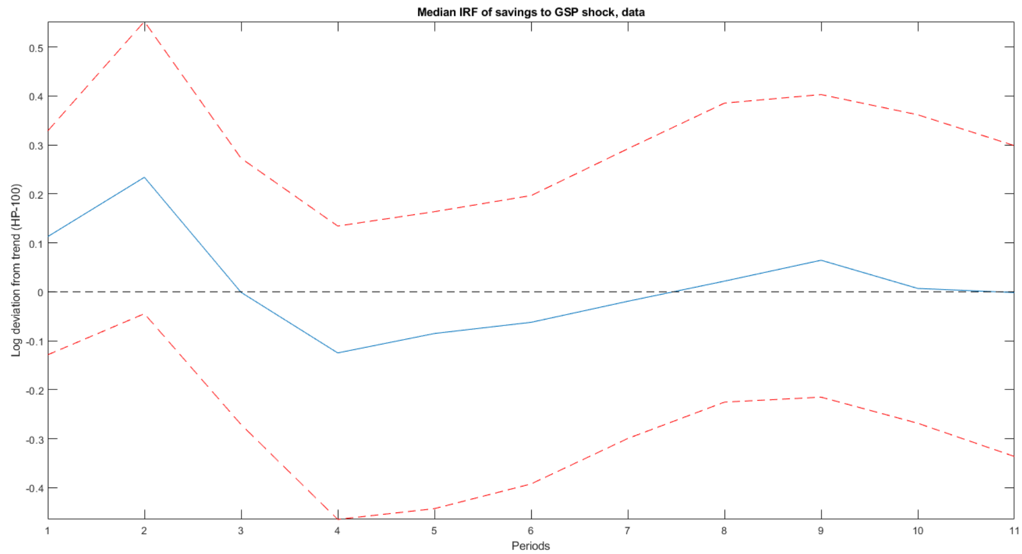
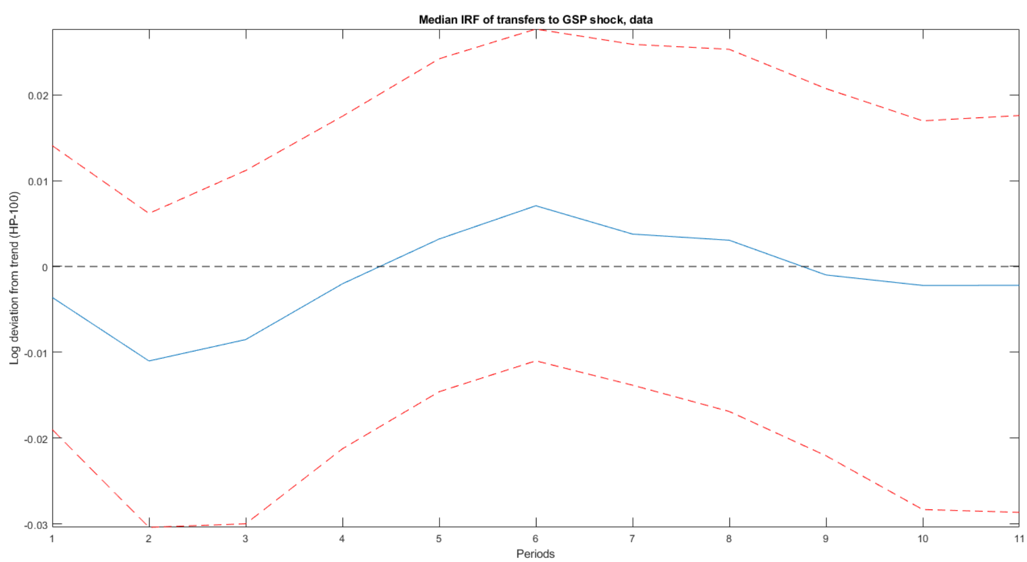


Figure 15



costs that large seem almost incredible. Certainly, in the real world, the frictions at the level of centralized policy making are more diverse; for example, political dynamics are likely an important part of a central government's inability (or unwillingness) to insure regions against adverse shocks. In the context of this model, all such frictions are being captured by the single noise parameter; nevertheless, its size implies a central government that is quite weak in responding to economic shocks at the regional level.

4.3 Model extensions

The baseline model makes an assumption on the nature of the central government's knowledge set; specifically, that the central government observes a noisy signal on the idiosyncratic state and beginning-of-period savings, but is not able to back out the previous period's idiosyncratic shock. This information structure is in the middle, so to speak, of two other possible setups, for which I present results in this section. I show that both model extensions behave in a qualitatively similar way to the baseline model, with only a couple key differences. These similarities suggest that the presence of this noisy signal is indeed the key driver of the quantitative results.

Model extension 1 allows the central government to perfectly back out the previous period's idiosyncratic state ϵ_{t-1}. This could either come from its observation of s_t or a lagged ability to obtain data on local economic conditions, and either interpretation is fine for the solution of the model. While extension 1 represents an improvement on the central government's ability to obtain information relative to the baseline model, extension 2 is a

Table 7: Business cycle moments

	Baseline Model	Data	Extension 1 (observes lag perfectly)	Extension 2 (does not observe savings)
$corr(y_t, T_t)$	-0.1457	-0.1536	-0.1999	-0.1485
$corr(y_t, s_t)$	0.2674	0.2862	0.2643	0.2588
$corr(y_t, y_{t-1})$	0.5205	0.5430	0.5319	0.512
$corr(T_t, T_{t-1})$	0.1670	0.3531	0.0420	0.1779
$corr(s_t, s_{t-1})$	0.9466	0.1072	0.9590	0.9405
$sd(y_t)$	0.0366	0.0281	0.0377	0.0387
$sd(T_t)$	0.0170	0.0694	0.0173	0.0134
$sd(s_t)$	0.0549	1.16	0.0619	0.0568

Note: moments reported here are for the cyclical components of each of these variables.

tighter restriction. In extension 2, the central government is not able to observe the region's savings account whatsoever; it must form an expectation about local savings based on its posterior beliefs and its knowledge of the regional government's policy function.

Moments from the simulations of the two model extensions, along with the baseline model and the data, are given in Table 7. For each of these extensions, I use the parameterization from the baseline model for direct comparison with the baseline model. The model extensions behave in many respects very similarly to the baseline model, especially extension 2, suggesting that the exact nature of the central government's relationship with information on local savings is not the key driver of the model. The main difference occurs in model extension 1, in which transfers are more correlated with regional business cycles, with a much lower autocorrelation. This is to be expected, given that the central government's prior is more accurate in this extension. The impulse response functions in these extensions unsurprisingly behave similarly in the extensions, with extension 1 displaying a stronger response of transfers to shocks, unsurprisingly with a one-period delay for the peak response, given that perfect information is revealed one period later.

4.4 Welfare analysis

The precautionary savings behavior in the model depends critically on the presence of a strict limit on deficits on the part of the regional governments. This is a realistic feature of the model, given the widespread use of such balanced budget rules in the real world. In this model, such rules are not a result of optimizing behavior, but external parameters imposed on the agents. There are no other frictions on policy at the local level; therefore, were balanced budget rules to be sufficiently relaxed, regional governments would be able to achieve the social planner solution of full consumption smoothing for the household. By studying the effects of removing this constraint, I can say something about the welfare loss imposed by the baseline model relative to the social planner, as well as examine the potential effects of removing a balanced budget constraint.

To compute social welfare in the region, I solve the model and then simulate it starting at $s_0 = 0$, $\epsilon_0 = 0$, with time-0 social welfare being given by the sum of discounted utilities. As ϕ is lowered, the model approaches the social planner outcome quite quickly; when $\phi \leq -0.10$, the model essentially matches the social optimum. The implied welfare loss of the balanced budget rule (combined with the frictions on the central government, of course), then, is about 2.1 percent of welfare in the social planner case. This is, of course, a sizeable number. All of this loss occurs in the early periods, when the regional government increases taxes in order to build up its stock of savings to its desired long-run level. From this point on, the household is *better off* than it would be in the no-balanced-budget case, due to the extra interest income for its government, but these gains are far outweighed by the losses in early periods.

4.5 Implications for fiscal policy

The model presented in this paper implies that significant structural frictions to optimal countercyclical fiscal policy making may exist at centralized levels of government. The magnitude of these frictions suggests that a role exists for U.S. states to participate in active fiscal policy over the business cycle. Clearly, as the data show, U.S. state governments do in fact save in order to manage public finances during downturns. The most visible vehicles for such savings are rainy day funds, but states have other avenues, as well.

I have avoided using the word "stimulus" thus far, as Keynesian-type stimulus does not appear in my model. However, it is likely that the presence of these frictions in the making of fiscal policy at the federal level imply that it may be optimal for U.S. states to engage in stimulus policy during recessions; this conclusion runs counter to a conventional wisdom going back at least as far as Oates (1972), though Gramlich (1997) does find a stimulus role for states. More work should be done to explicitly model the implications of information and other political frictions for state-level fiscal policy over the business cycle.

Of note as well is the analysis of the effects of balanced budget rules in this model. In the information model presented here, removing the balanced budget rules completely eliminates welfare losses from baseline model, allowing regional governments to smooth completely over the business cycle. Of course, the assumption is that there are no real costs to borrowing, no default risk, etc. It may be that, in the real world, the balanced budget rules for U.S. are optimal responses to real costs of debt finance. In that case, the policy implications of loosening balanced budget rules would be completely the opposite: a welfare loss instead of a welfare gain.

Finally, these results may have something to say about the debate over fiscal policy in Europe. The results in this paper serve as a caution to potential efforts to establish a European fiscal union. While the ability of a such a union to finance spending with a deficit would be an advantage, there may be significant frictions to effective and timely fiscal stimulus along the lines of the frictions identified in this paper. Such frictions may prevent the effective smoothing of risks across countries, working against the stated purpose of unionization. In the presence of significant information or political frictions to optimal policy, a fiscal union in Europe may have trouble responding to localized shocks, especially as diverse an economic environment as the Eurozone.

5 Conclusion

This paper identified three key facts about the public finances of U.S. state governments over the business cycle, in the context of the role of the U.S. as a strong fiscal union. First, state governments engage in precautionary savings, in large part due to balanced budget requirements. Second, transfer payments from the federal government tend to respond more strongly to the aggregate business cycle than to state-level economic cycles. Third, states whose business cycles are less correlated with the national cycle tend to save more relative to other states. In light of the first two facts, I interpret the third fact as an indication that federal transfers (or lack thereof) influence state government savings behavior.

To give structure to this interpretation, I turn to a modeling framework in which I interpret a U.S. state as a small open endowment economy in a fiscal federation. Both levels of government, regional and central, may conduct fiscal policy, but each is faced with a different friction. Regional governments face borrowing limits, but central governments are faced with an information friction (which may also be interpreted as a political friction). The information friction prevents the central government from perfectly smoothing over the cycle, and thus regional governments must engage in precautionary savings.

I find that the model fits many qualitative features of the data well, and conclude that it is a useful framework in which to begin thinking about state government finances. The implied information friction is almost three times as large as real volatility; this is a formidable friction implying a central government with little ability to smooth over idiosyncratic cycles for states. Two variations on the structure of the information available to the central government yield quantitatively similar results. The baseline calibration also implies a long-run welfare loss of two percent relative to the social optimum. These results imply that frictions to policy making at the central level may be a significant factor in fiscal policy at the state level.

I conclude, contrary to some conventional wisdom, that space exists for states to actively pursue robust fiscal policies over the business cycle; furthermore, states that save are behaving optimally given their constraints. To the extent that central governments are constrained by a lack of information or stymied by politics, they may not be able to perfectly implement a first-best countercyclical fiscal policy. Of course, more research is needed into the size and nature of these frictions to policy, especially as they relate to recessions and expansions. Federalism, its complexities and mysteries notwithstanding, remains an important vehicle through which policy makers can insure citizens against adverse outcomes.

Appendices

A Determination of transfer equation using IV

Equation 1 relates the transfers from the federal government received by state government i to, among other things, gross state product of state i and the sum of the gross state products of other states $-i$. A clear potential source of endogeneity in this equation is the effect of transfers on output, especially since these data are only available at the annual frequency. As a robustness check, I instrument $y_{i,t}$ and $y_{-i,t}$ with monetary policy shocks at the annual level. I use the annual shocks from Weiland and Yang (2019), which correspond to the shocks in Romer and Romer (2004), updated through 2007. These shocks are publicly available online at Johannes Weiland's webpage.[18]

Table 8 shows the results of the instrumental variables regression. The response of transfers to the business cycle is much greater for $y_{-i,t}$, and the sign on $y_{i,t}$ flips, suggesting that perhaps the main results underestimate the true difference in reponses. Furthermore, the qualitative relationship between the two equations holds: fiscal transfers from the federal government respond more strongly to aggregate business cycle conditions than local conditions, even though the transfers are to specific state governments. These regressions should be taken with a grain of salt, however, given that the instruments may not be incredibly strong.

[18] https://sites.google.com/site/johannesfwieland/

Table 8: Determinants of state government receipts from federal government, IV

Variable	$\log(pop)$	$\log(GSP_i)$, cyclical	$\log(GSP_{-i})$, cyclical
Coefficient	0.1728*	3.314*	-8.290**
(s.e.)	(0.0915)	(1.937)	(4.128)

Note: Results from a fixed-effects instrumental variables regression with standard errors clustered at the state level. The instruments are monetary shocks described in the text. Observations include 46 states for which holes do not exist in the Census of Governments data from 1981 to 2012. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.

B Extended regression results

This section provides the full results from the regressions provided in the main body of the paper. The extra variables in these tables are listed and explained below:

- Log(debt): The log of a state government's real debt
- Debt / GSP: The stock of a state government's debt as a share of its gross state product.
- Governor is democrat: = 1 if the state's governor is a member of the Democratic party, reported in the Center for Poverty Research data.
- Variance of cyclical GSP: the variance over time of the state's HP-filtered gross state product, a time-invariant variable for each state.
- Balanced budget strictness: measure of the strictness of the state's balanced budget rules, constructed from Hou and Smith (2006), which classify 9 possible restrictions on budgets. Sums the rules each state has adopted, weighting the 'stricter' rules more heavily.

Table 9: Determinants of State Government Balances

Dependent variable	log(∼ Real balances)			Real balances / GSP			Real balances / Expenditures		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Business cycle correlation	-0.0920**	-0.0825*	-0.0847*	-0.0054***	-0.0038**	-0.0038**	-0.0412***	-0.0262**	-0.0262**
	(0.0412)	(0.0466)	(0.0468)	(0.0016)	(0.0015)	(0.0015)	(0.0144)	(0.0128)	(0.0127)
Log(GSP), cyclical	0.5505***	0.4131**	0.1138	0.0225***	0.0177***	0.0167***	0.3036***	0.2536***	0.2487***
	(0.1886)	(0.1885)	(0.0789)	(0.0042)	(0.0050)	(0.0063)	(0.0377)	(0.0454)	(0.0547)
Log(GSP), cyclical * High correlation	-	-	0.9854*	-	-	0.0031	-	-	0.0155
			(0.5528)			(0.0068)			(0.0652)
Log(GSP)	0.0537***	0.0570***	0.0577***	-	-	-	-	-	-
	(0.0124)	(0.0131)	(0.0132)						
Log(debt)	-	0.0041	0.0020	-	-	-	-	-	-
		(0.0065)	(0.0072)						
Debt / GSP	-	-	-	-	6.29e-6	6.30e-6	-	2.76e-5	2.76e-5
					(4.46e-6)	(4.47e-6)		(4.47e-5)	(4.49e-5)
Governor is Democrat	-	-0.132*	-0.0120*	-	-0.0002	-0.0002	-	-0.0027	-0.0027
		(0.0068)	(0.0069)		(0.0003)	(0.0015)		(0.0028)	(0.0028)
Variance of cyclical GSP	-	9.335**	9.572**	-	0.8860***	0.8870***	-	9.260***	9.265***
		(4.308)	(4.240)		(0.2214)	(0.2215)		(2.199)	(2.199)
Balanced budget strictness	-	0.0001	3.61e-5	-	-5.23e-6	-5.27e-6	-	5.16e-5	5.14e-5
		(0.0011)	(0.0010)		(4.51e-5)	(4.52e-5)		(0.0005)	(0.0005)

Note: The sample for these regressions is 49 U.S. states (Alaska not included) for the years 1981-2012. The regressions are according to a random effects model. Standard errors are clustered at the state level. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 10: Determinants of State Government Net Assets (not incl. insurance funds)

Dependent variable	log(∼ Real net assets)			Real net assets / GSP			Real net assets / Expenditures		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Business cycle correlation	-1.2630***	-1.2365***	-1.2320***	-0.1168***	-0.0605**	-0.0607**	-1.0787***	-0.5528***	-0.5541***
	(0.3325)	(0.3857)	(0.3845)	(0.0393)	(0.0267)	(0.0267)	(0.3393)	(0.2115)	(0.2118)
Log(GSP), cyclical	0.9278**	0.5754	0.0538	0.0513*	0.0581*	0.0202	0.9424***	1.0980***	0.9055***
	(0.3416)	(0.6129)	(0.6406)	(0.0274)	(0.0328)	(0.0381)	(0.1349)	(0.1655)	(0.2011)
Log(GSP), cyclical * High correlation	-	-	1.8011**	-	-	0.1196***	-	-	0.6059**
			(0.7729)			(0.0413)			(0.2714)
Log(GSP)	0.1993**	0.3001***	0.2979***	-	-	-	-	-	-
	(0.0834)	(0.0857)	(0.0852)						
Log(debt)	-	-0.0761	-0.801	-	-	-	-	-	
	-	(0.0582)	(0.0578)						
Debt / GSP	-	-	-	-	-5.42e-6	-4.91e-6	-	-0.0003	-0.0002
	-				(2.31e-5)	(2.36e-5)		(0.0002)	(0.0002)
Governor is Democrat	-	-0.0152	-0.0135	-	-0.0031	-0.0029	-	-0.0205	-0.0197
		(0.0482)	(0.0478)		(0.0025)	(0.0025)		(0.0272)	(0.0272)
Variance of cyclical GSP	-	41.87	41.80	-	25.64***	25.68***	-	237.8***	238.0***
		(43.14)	(42.86)		(5.479)	(5.486)		(60.83)	(60.82)
Balanced budget strictness	-	-0.0190	-0.0191	-	-0.0018***	-0.0018***	-	-0.0173***	-0.173***
		(0.0119)	(0.0118)		(0.0007)	(0.0007)		(0.0066)	(0.0066)

Note: The sample for these regressions is 49 U.S. states (Alaska not included) for the years 1981-2012. The regressions are according to a random effects model. Standard errors are clustered at the state level. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

C Equivalence of central government budget models

In this section I show that the two alternatives for formulating the budget constraint of the central government with respect to smoothing idiosyncratic shocks result in equivalent transfer policy rules. The first alternative is the no-Ponzi-game condition from Equation 8:

$$\lim_{t\to\infty} \mathbb{E}_0\Big[\frac{A_t}{(1+r)^t} = 0\Big].$$

This constraint prevents the central government from accumulating debt indefinitely. This constraint is valid for an economy with any number of regions.

The second alternative assumes that transfers to smooth for idiosyncratic shocks must be paid for in the current period. If regions are indexed by i, this constraint takes the form $\sum_i T_{it} = 0$ for all t, and for an infinite number of regions it is expressed as in Equation 9:

$$\int T_{it} di = 0.$$

Proposition 1. *If all regions are ex ante identical, then the no-Ponzi-game budget constraint is equivalent to the period budget constraint for a continuum of regions, as both result in the condition* $\mathbb{E}_0\big[T(s_t, \theta_t, f_t)\big] = 0$.

Proof. Consider first the period budget constraint with an infinite number of *ex ante* identical, but heterogeneous, regions. By the law of large numbers, in every period the distribution over the state variables will yield densities equal to the long-run probabilities of each state. Since the transfer policy function for idiosyncratic shocks will be the same for every region, its distribution will also equal the long run distribution. This results in $\int T(s_{it}, \theta_{it}, f_{it}) di = \mathbb{E}_0\Big[T(s_{jt}, \theta_{jt}, f_{jt})\Big]$ for any region j, which, when plugged into the budget constraint yields $\mathbb{E}_0\Big[T(s_{jt}, \theta_{jt}, f_{jt})\Big] = 0$ for any region j.

Now observe the no-Ponzi-game budget constraint. This allows the central government to hold unlimited assets A_t for the purposes of smoothing idiosyncratic shocks. If regions are *ex ante* identical, then it is without loss of generality to consider a separate fund A_{it} for each region for the purposes of solving for the transfer function $T(s_{it}, \theta_{it}, f_{it})$, which will be the same in each region. The law of motion for A_{it} is given by $A_{it+1} = A_{it}(1+r) + (-T(s_{it}, \theta_{it}, f_{it}))$, which can be expanded and solved to yield $A_{it+1} = -\sum_{j=0}^{t} T(s_{it-j}, \theta_{it-j}, f_{it-j})(1+r)^j$. Plugging in to the budget constraint, the condition now becomes

$$\lim_{t\to\infty} \mathbb{E}_0 \left[-\sum_{j=0}^{t-1} T(s_{it-(1+j)}, \theta_{it-(1+j)}, f_{it-(1+j)})(1+r)^{(j-t)} \right] = 0$$

$$\Rightarrow \lim_{t\to\infty} -\sum_{j=0}^{t-1} \mathbb{E}_0 \Big[T(s_{it-(1+j)}, \theta_{it-(1+j)}, f_{it-(1+j)}) \Big] (1+r)^{(j-t)} = 0.$$

This can only be satisfied if $\mathbb{E}_0 \Big[T(s_{it}, \theta_{it}, f_{it}) \Big] = 0$ for all regions i. $\square$

D Long-run posterior variance

In this section I show that a long-run stable value for the posterior variance exists and solve for its value. First, I derive the law of motion for the posterior variance. Beginning with posterior $\hat{\sigma}^2_{\mu,t}$ in time t, the prior for next period is formed as in Equation 14: $\sigma^2_{\mu,t+1} = \rho^2_\epsilon \hat{\sigma}^2_{\mu,t} + \sigma^2_{\xi^\epsilon}$. Next period's posterior is then formed according to Equation 12: $\hat{\sigma}^2_{\mu,t+1} = \frac{\sigma^2_{\mu,t+1}\sigma^2_{\xi^\theta}}{\sigma^2_{\mu,t+1}+\sigma^2_{\xi^\theta}}$. Combining these two yields the law of motion for the posterior variance:

$$\hat{\sigma}^2_{\mu,t+1} = \frac{(\rho^2_\epsilon \hat{\sigma}^2_{\mu,t} + \sigma^2_{\xi^\epsilon})\sigma^2_{\xi^\theta}}{\rho^2_\epsilon \hat{\sigma}^2_{\mu,t} + \sigma^2_{\xi^\epsilon} + \sigma^2_{\xi^\theta}}. \tag{16}$$

Defining the function $h(x) = \frac{(\rho_\epsilon^2 x + \sigma_{\xi^\epsilon}^2)\sigma_{\xi^\theta}^2}{\rho_\epsilon^2 x + \sigma_{\xi^\epsilon}^2 + \sigma_{\xi^\theta}^2}$ and taking the limit as $x \to \infty$, it is clear that $h(x)$ converges to a finite value: $\lim_{x\to\infty} h(x) = \sigma_{\xi^\theta}^2$. Therefore, we can argue that $\hat{\sigma}_{\mu,t+1}^2 = h(\hat{\sigma}_{\mu,t}^2)$ is bounded on $\mathbb{R}^+$. Now assume that $\hat{\sigma}_{\mu,0}^2$ is initialized in a region such that it converges to the fixed point of $h(x)$; this fixed point then defines the long run value, and solving for it is straightforward:

$$\hat{\sigma}_{\mu,\infty}^2 = \frac{(\rho_\epsilon^2 \hat{\sigma}_{\mu,\infty}^2 + \sigma_{\xi^\epsilon}^2)\sigma_{\xi^\theta}^2}{\rho_\epsilon^2 \hat{\sigma}_{\mu,\infty}^2 + \sigma_{\xi^\epsilon}^2 + \sigma_{\xi^\theta}^2}$$

$$\rho_\epsilon^2 (\hat{\sigma}_{\mu,\infty}^2)^2 + (\sigma_{\xi^\epsilon}^2 + \sigma_{\xi^\theta}^2 - \sigma_{\xi^\theta}^2 \rho_\epsilon^2)\hat{\sigma}_{\mu,\infty}^2 - \sigma_{\xi^\theta}^2 \sigma_{\xi^\epsilon}^2 = 0$$

Solving for the positive solution of the quadratic formula yields the result in Equation 15:

$$\hat{\sigma}_{\mu,\infty}^2 = \frac{(\rho_\epsilon^2 - 1)\sigma_{\xi^\theta}^2 + \sigma_{\xi^\epsilon}^2 + \sqrt{\left[(\rho_\epsilon^2 - 1)\sigma_{\xi^\theta}^2 + \sigma_{\xi^\epsilon}^2\right]^2 + 4\rho_\epsilon^2 \sigma_{\xi^\theta}^2 \sigma_{\xi^\epsilon}^2}}{2\rho_\epsilon^2}.$$

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