Public Employee Pensions and Municipal Insolvency*  

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Abstract  

This paper studies how governments manage public employee pensions and how this affects insolvency risk. I propose a quantitative model of governments that choose their savings and risk exposure by borrowing/saving in defaultable bonds, borrowing in non-defaultable pension benefits, and saving in a pension fund that earn a risk premium. In insolvency, the government can receive transfers from households who may differ from the government in their preferences for public services and private consumption. I match the model to a panel of CA cities and a hand-collected record of fiscal emergencies. The model predicts that governments are highly vulnerable to another stock market bust. A hypothetical shock to pension funds in 2015 produces twice as many fiscal emergencies as the original 2008-10 shock. In the quantified model, the government undersaves and takes excess risk relative to what households would choose. Savings requirements that limit spending to essential services plus 0.3% of cash-on-hand produce large welfare gains for households. Requiring the pension fund to invest more in safe assets decreases household welfare because the lower average return discourages the government from saving.

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1 Introduction

How do governments manage public employee pensions and how does this affect the risk of government insolvency? Across the US, state and local governments run large pension plans for public employees and invest in risky pension funds. A survey of 190 of the largest plans found that liabilities totaled $5.1 trillion and pension fund assets totaled $3.7 trillion, with 70% of assets invested in equity. Due to large pension fund losses during the financial crisis and the size of liabilities, public employee pensions have played a central role in recent government insolvencies, such as the Detroit and Stockton bankruptcies. This begs the question, what will happen if there is another stock market bust and should government policy be changed to reduce insolvency risk?

I propose a model of government decisions where the government not only chooses its spending and outstanding bonds, but also its pension liabilities and investment in a pension fund that earns a risk premium. The government provides services for households and can default on outstanding bonds and pension liabilities, but at different costs. If services are low enough that households are willing to provide a transfer to pay for additional services, the government can declare insolvency. High bond debt, pension liabilities, and exposure to pension fund risk raise the chance of insolvency. Conversely, transfers in insolvency incentivize the government to borrow and take risk by accumulating more bond debt and pension liabilities and saving in the risky pension fund instead of bonds. Matched to a panel of California cities and a hand-collected record of fiscal emergencies, the model estimates that savings requirements can produce large welfare gains for households while investing the pension fund in safer securities actually reduces household welfare.

At the heart of the model is an agency conflict between households and the government, where the government does not value the cost to households of providing transfers. As a result, the government underweights bad states relative to households, causing undersaving and excess exposure to risk. Importantly, government incentives become more skewed as it gets closer to insolvency, so the parameters governing preferences can be estimated from how California cities responded to the 2008 shock to pension fund assets and by comparing cities that had larger or smaller losses. The main finding is that cities had low savings overall after the crisis and the cities closest to insolvency took more risk. Savings requirements can produce large welfare gains because they move the government away from the insolvency region. As the likelihood of insolvency decreases, government incentives become less skewed which also reduces excess risk-

\[^1\text{Center for Retirement Research at Boston College, Public Plans Data.}\]
taking. Requiring the pension fund to save in safer securities lowers the average return on the fund, which reduces the government’s incentive to save. Thus, it reduces excess risk-taking but worsens undersaving, which produces a welfare loss for households in the quantified model.

As with any debt, the first question for pension liabilities is whether they will need to be paid. Using settlement details for all US city bankruptcies since 2008 as well as historical data for California back to 1967, I show that pension liabilities are senior to bonds. In California, they are effectively non-defaultable, meaning they are almost always fully paid. Because pension liabilities are non-defaultable, bond spreads will be imperfect measures of fiscal health. Cities with low outstanding bonds will have little incentive to default, even if they have large pension liabilities. Instead, I measure fiscal health by collecting a novel record of fiscal emergencies, which are a form of service-level insolvency, across all CA cities. I then construct a panel of bond and pension finances for all CA cities which shows (i) the pension system dwarfs outstanding bonds by an order of magnitude, (ii) cities have large negative net wealth because pension liabilities exceed pension assets, and (iii) cities are highly levered with large pension and bond liabilities and large risky pension funds. There is also substantial heterogeneity across cities, with some having much lower net wealth and higher levered exposure to risk.

To understand how these three findings affect insolvency risk, the model features governments whose revenues depend on aggregate and idiosyncratic shocks and pension funds whose returns also depend on the aggregate shocks. Each period, the government chooses how much to spend on services, invest in the pension fund, and borrow or save in one-period bonds. Pension benefits are non-tradable and accrue based on the amount the government spends on services. While the government has the ability to default on both benefits and outstanding bonds, it endogenously chooses to only ever default on outstanding bonds, since public employees can punish the government much more severely than creditors. The decision to declare insolvency in order to ask households for a transfer is the result of a game between the government and local households. In equilibrium, the government declares insolvency if services fall below a threshold of essential services.

The main trade-offs faced by the government are spending versus saving and saving more in the risky fund versus saving more or borrowing less in bonds. Because the government receives transfers from households in insolvency, it is partially insured against bad states. This skews the government’s incentives and causes overspending and excess exposure to risk relative to what households would want. In the model, this explains the

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2 The mayor of San Diego stated this exact rational for not defaulting in 2010, as quoted in Section 2.4.
low net wealth and high levered exposure to risk that I document in the data.

Using the panel of city finances and the quantified model, I perform three sets of tests. First, I test the ability of cities to handle another stock market bust similar to 2008. While one might expect that cities would increase savings and reduce risk exposure after the financial crisis, I find that the same shock to pension funds in 2015 would cause more than twice as many cities to declare insolvency as the original 2008-2010 shock, 143 out of 475 cities compared to only 57. While the panel ends in 2015, I also show that the positive returns on the pension fund for 2016-2019 do not change this result. Second, I calculate a constrained optimum where households choose spending and risk exposure. Compared to cities’ actual choices after the 2008-2010 shock, households would choose to save substantially more and would reduce levered risk exposure, particularly for the cities closest to insolvency. Starting at the 2010 empirical state variables, the welfare gain from switching to the constrained optimal choices is large at 0.85% of lifetime consumption and 2.10% of lifetime services.

Given that the government overspends and takes excessive risk, the final set of tests are policy experiments imposing savings requirements and reducing the riskiness of the pension fund. I find that relatively simple savings requirements produce large welfare gains for households; the policy produces over 90% of the welfare gain from moving to the constrained optimum. Forcing cities to save more moves them away from the insolvency region which reduces the effect of insolvency transfers on government incentives. The effect is similar to capital requirements for banks that reduce moral hazard from deposit insurance. In contrast, requiring the pension fund to invest more in safe assets actually reduces household welfare. The lower average return reduces the government’s incentive to save, and the benefits of reducing risk exposure are quantitatively outweighed by the costs of worsening overspending.

A key element of the model is that households have a higher preference for private consumption than the government, which means the government does not fully value the cost to households of providing transfers in insolvency. I motivate this preference structure in two ways. First, in California, city governments cannot independently change taxes; they must get household approval through a vote. If governments were benevolent, households would give them full control over taxes, so this indicates that households believe the government would overtax if allowed. Second, this structure for preferences predicts that as cities get poorer, they will take on more risk to exploit the fact that households will provide transfers if the city becomes insolvent. I document

\footnote{For example, until 1984 California only allowed pension funds to place 25% of their assets in stocks. Funds currently place roughly 60% in stocks.}
that this type of risk-shifting not only occurs in the data, but was a major factor in recent bankruptcies. Cities can increase their exposure to risk premia by issuing specific bonds (POB’s) where all proceeds are invested in the risky pension fund. I find that the poorest California cities use POB’s and that over 70% of the bonds eliminated in US city bankruptcies since 2008 were POB’s.

Since model overspending and excess risk become worse as cities approach insolvency, I quantify the model to match the response of cities to an unexpected drop in wealth during the financial crisis. I split cities into two groups based on population in order to compare cities that were more and less affected by the pension fund losses. Large and small cities provide a different mix of services with large cities spending more on labor-intensive services. Because of this, large cities run bigger pension systems relative to revenue. The model successfully matches the savings, risk exposure, and pension decisions of both groups and as well as the total number of cities that declare insolvency, the number of cities that default, and the average bond spread. Additionally, the model correctly predicts that large cities will be more likely to declare insolvency, even though small cities receive more volatile revenue shocks. Moreover, the model also correctly predicts that cities with higher pension funds relative to revenue before the crisis will be more likely to declare insolvency even after controlling for whether the city is large or small.

Related literature

This paper is related to several strands of literature. The first is the empirical literature on unfunded public pensions and how pension liabilities should be measured. Novy-Marx and Rauh (2009, 2011), Brown and Wilcox (2009), Brown and Pennacchi (2016), and Rauh (2017) show that state and local governments have large unfunded pensions and that the reported values for pension liabilities understate governments’ obligations. Pension benefits are promises for safe payments, so these papers calculate the liabilities for pension plans by discounting benefits at the return on safe assets and show that this is much larger than the values reported by governments, who discount at the average return on the pension fund. To account for this, I match the stream of benefit payments in the model to data directly, rather than computing the discounted value. Given the size of current unfunded pensions, Novy-Marx and Rauh (2014) calculate that contributions would need to increase substantially to achieve full funding and Anzia et al. (2019) confirm that government pension contributions are rising across the US. Novy-Marx and Rauh (2012) also find that pension fund losses for states increase the spread on their municipal bonds. The empirical component of my paper adds to this literature by

4Unfunded pensions are the difference between pension liabilities and pension assets.
constructing a city-level dataset of pension assets, liabilities, and bond spreads and combining this with data on city bonds outstanding and a novel record of fiscal emergencies, which will both be relevant for my model.

Since the model government does not value the cost to households of providing transfers, my analysis is closely tied to empirical work documenting risk-shifting in public pension funds. State and local governments delegate the investment of their pension fund to a board of trustees. Pennacchi and Rastad (2011), Bradley et al. (2016), and Andonov et al. (2017) show that boards with more politicians or public employee representatives invest in riskier assets. Importantly, all three papers as well as Mohan and Zhang (2014) find that boards increase risk exposure when benefits are more underfunded or after negative shocks to pension assets. In comparison, private pension plans invest in safer assets when benefits are more underfunded (Rauh (2008)). I examine this same incentive to risk-shift for the government rather than the board. In addition to any excess risk that the board may take by investing the fund mainly in risky securities, governments can increase their risk exposure by issuing their own bonds and putting more money into the pension fund.  

On the theoretical front, my model builds on a large literature on sovereign default (Eaton and Gersovitz (1981); Aguiar and Gopinath (2006); Arellano (2008); see Aguiar et al. (2016) for a survey). These papers study the borrowing and savings decisions of a government with limited commitment to repaying bonds and show how the endogenous choice of default risk can explain the joint dynamics of income, borrowing, and spreads as well as the frequency of default.

A recent development in this literature is the inclusion of multiple tiers of liabilities. Hatchondo et al. (2017) study the potential creation of non-defaultable Eurobonds for EU nations. The amount of Eurobonds is exogenously capped, and the government always issues the maximum amount, except during a transition period after the bonds are introduced. Boz (2011), Fink and Scholl (2016), and Pancrazi et al. (2017) analyze non-defaultable loans from international financial institutions such as the IMF that can only be accessed if the government agrees to “conditionality clauses” that restrict their future spending. These papers highlight how access to non-defaultable bonds can lower spreads during times of crisis by reducing the need of the government to borrow in defaultable bonds. In contrast, this paper studies the choice of a government to issue defaultable and non-defaultable debt without caps or restrictions on spending and shows how non-defaultable debt can increase the risk of insolvency. Myers (2017) similarly

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5 As discussed above, this was a major part of recent city bankruptcies, with Detroit, Stock, and San Bernardino all issuing large amounts of POB’s.
looks at the effect of pensions on government borrowing at the national level, but focuses on the role of defaultable pay-as-you-go pensions in increasing the government’s ability to commit to repaying bonds.

Another new feature of the model is that I allow the government to invest in assets that earn a risk premium. Alfaro and Kanczuk (2009) and Bianchi et al. (2018) study the choice of a government to save in risk-free reserves to offset its defaultable bond liabilities. I also allow the government to save in a risk-free asset but extend its investment options to include risky assets that earn higher returns that are correlated with the government’s revenue growth. Because the government can default, it is partly insured against bad shocks which increases its incentive to take risk. Thus, the core mechanism in these models which drives borrowing and default will also affect savings in risky assets. This incentive is strengthened by the fact that the government can also receive transfers from households in bad states.

Two recent papers have extended these models to the sub-national level. While sub-national governments are often more constrained due to legal restrictions from national governments and limited control over households, they still hold the key feature for sovereign default models which is that the government always continues to exist. While private companies can be dissolved to pay off creditors, state and local governments endure which means their decisions will depend heavily on the continuation values. Arellano et al. (2016) and Gordon and Guerron-Quintana (2019) study US states and cities, respectively. Both studies focus on the government’s choice of bonds, while this paper also incorporates the government’s choice of pension benefits and pension fund assets, which I show are an order of magnitude larger than bonds outstanding for CA cities. Moreover, 70% of bonds outstanding eliminated in recent city bankruptcies were bonds issued to invest in pension funds, so city pension decisions will be important for explaining bond borrowing and default. Additionally, the inclusion of non-defaultable pension benefits and risky pension funds substantially increases cities’ total liabilities and exposure to risk.

Outside of the sovereign default literature, previous papers have modeled the decision to underfund pensions in deterministic economies (Mumy (1978); Epple and Schipper (1981); Inman (1982); Brinkman et al. (2018)). Glaeser and Ponzetto (2014) incorporate risk from voter decisions into a model of local government spending. Lucas and Zeldes (2009) study the government’s decision to invest its pension fund in safe or risky assets in a two-period model with fixed contributions and benefits. Pennacchi and Rashad (2011) extends this choice of risk exposure to an infinitely lived government with an exogenous process for benefits and no contributions. This paper combines the choice
of underfunding and risk exposure and shows important interactions between the two decisions. As unfunded pensions become larger relative to revenue, the city will have an incentive to increase risk exposure and restrictions on the riskiness of the pension fund will affect the government’s incentive to fund pension benefits.

Lastly, several empirical and theoretical papers have shown that the large tax-adjusted spread on municipal bonds can be explained by default premia, despite the low frequency of default (Trzcinka (1982); Yawitz et al. (1985); Stock (1994); Liu et al. (2003); Schwert (2017)). In these papers, default is exogenous. In comparison, my model endogenizes both the default decision and the choice of bonds. When parameters are set to match bond spreads and other key empirical moments, the model predicts that there must be a small probability state where many cities default and creditor pricing kernels are high. Intuitively, the model cities would simply choose not to borrow if the high spreads were due to large inefficiencies of default or a large mismatch between creditors’ and governments’ risk-aversions.

Layout

The remainder of the paper is organized as follows. Section 2 uses data on California cities to establish key stylized facts about savings, borrowing, and levered risk exposure and tests the defaultability of pension benefits. Section 3 describes a quantitative model in which the government can borrow or save in defaultable bonds, borrow in non-defaultable pension benefits, and save in a risky pension fund. Additionally, the government plays a game with households for insolvency transfers. Section 4 quantifies the model to match the response of cities to the financial crisis. Section 5 estimates the risk of future insolvencies, calculates the constrained optimum for households, and asks what policies could move the economy closer to the constrained optimum. Section 6 concludes.

2 Data and Facts

To understand how cities choose their risk exposure and borrowing, and how this affects the chance of insolvency, I will need data on three things: (i) the size and state-contingency of city pension assets, pension liabilities, and bonds outstanding, (ii) city borrowing costs, and (iii) city insolvencies. In this section, I first give an overview of how the pension system operates in California cities, then present a panel dataset of pension assets, pension liabilities, and bonds outstanding across all California cities for 2008-2015. On average, pension assets and liabilities both dwarf the size of bonds outstanding in all years, making the pension system the main component of city balance
sheets. However, there is considerable variation across cities in the size of their balance sheets and in the composition of total pension and bond liabilities.

To test the state-contingency of pension liabilities relative to bonds, I use settlement details from municipal bankruptcies and show that pension liabilities are less state-contingent than bonds, i.e. they are harder to default on. For California, pension liabilities appear virtually non-defaultable. I then detail a novel dataset of fiscal emergencies that I hand-collect for all California cities in order to test predictions on insolvency risk, as well as data on municipal bond spreads that will be used to estimate borrowing costs and default risk. Lastly, I discuss the use of discount rates when calculating pension liabilities and how to account for this by modeling benefit payments rather than a present discounted value.

### 2.1 Pension system details

City governments pay their employees with a mix of wages and defined pension benefits. For example, a retiring worker will know that based on her years of employment and salary history, she will receive $50,000 a year plus cost of living adjustments for the rest of her life. To pay these future benefits, cities put money into a pension fund. These pension funds are highly exposed to risk, with funds typically investing 60% in equity, only 20% in fixed income, and the remainder in real estate and other securities. Over 95% of all California city pension funds are run through a third-party called CalPERS which invests all of the funds into the exact same portfolio, and the remaining 5% of funds invest in a very similar mix of securities as the CalPERS portfolio. This means that while the returns on the pension funds can vary substantially year to year, there is little variation across cities within each year.

When measuring a city’s pension finances, the main variables are the pension assets and liabilities. The pension assets are simply the amount of money in the city’s pension fund. Legally, cities are not allowed to invest in risky securities with the exception of their pension funds, and the city government does not control the portfolio weight on risky securities, as the funds are run by third-parties such as CalPERS or independent pension systems. This means that the city government can only control its holdings of risky securities by putting more or less money into the fund. For example, some cities issue bonds and place the proceeds into the pension fund to increase their exposure to risk premia.

The pension liabilities are the present value of benefits discounted at the average rate of return on the pension fund. In other words, the liabilities measure how much money needs to be in the pension fund today so that, on average, the pension fund will be able
to pay these benefits in the future. I do not include the full projected value of benefits that employees are expected to earn over their careers. I only include a portion of the future benefits based on how much they have already worked. Viewing the pension benefits as a special type of bond, I only want to count the bonds that have already been used to pay employees.

Once the pension liabilities and pension assets are measured, it is useful to discuss the difference between the two, which is the unfunded pensions. This measures how much additional money the city needs to put into its pension fund for it to cover the accrued benefits on average. Even if no new benefits are accrued and the pension fund grows in line with its average return, unfunded pensions will increase over time if a city does nothing. Specifically, suppose a city has $1 in unfunded pensions. That dollar was supposed to be in the pension fund earning interest to pay future pension benefits. Unless the city acts to decrease benefits or increase assets, its next year unfunded pensions will be $1 + r dollars. This is analogous to rolling over bond debt and implies that cities that wait to address their unfunded pensions will have to make larger changes to pension assets or benefits.

2.2 Panel of city finances

I construct a panel of annual data on city finances from 2008-2015 for all California cities. This is done by merging data on the pension systems with city financial statements. The pension data is taken from actuarial valuation reports provided by CalPERS or the individual cities. As discussed earlier, 95% of all city pension plans are run through CalPERS. The cities still retain control over the pension plans, such as deciding how much to offer employees in pension benefits and how much to place in the pension fund. CalPERS simply manages the investment of the pension fund and the payouts to retirees. For these pension plans, the annual data is collected directly from CalPERS, specifically from the public agency actuarial valuation reports. For plans that are not run through CalPERS, the data is collected from the Required Supplementary Information section of their Comprehensive Annual Financial Report. The main variables are the pension assets and pension liabilities.

Data on city finances comes from the City Financial Transactions Reports (CFTR). Each year, cities must file this report with the State Controller’s Office (SCO) based

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6The liabilities are calculated using the Entry Age Normal actuarial method. Under this method, the accrued liability owed to employees increases by a constant percentage of their wages each year that they work. This aligns well with the model, where new liabilities accrue as a constant percentage of total expenditure on services.

7I am grateful to Joe Nation and Pension Tracker for providing access to the pension data.
The main variables taken from these reports are the annual city revenue and bonds outstanding. Since many small cities mainly use loans instead of issuing municipal bonds, I also include all loan debt in the measure of bonds outstanding.

### 2.2.1 Time series

Figure 1 shows the time series for pension liabilities, pension assets, and bonds outstanding as a percent of revenue averaged across all cities. The most prominent feature of this graph is that the pension system dwarfs the bonds outstanding, with pension liabilities and pension assets always averaging above 100% of revenue while bonds outstanding only range from 16%-22% of revenue. This means that the pension system is a significant part of city finances and should be incorporated when discussing a city’s fiscal health. This also changes the common conception of a city government from a simple entity that issues bonds to finance services to something more akin to a hedge fund that sells large amounts of safe bonds and pension liabilities and invests heavily in risky assets.

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*Three cities (Loyalton, Tulelake, Westmorland) are excluded from the panel due to missing data. Combined these three cities only represent 0.012% of the total population for the 478 California cities. For Tulelake and Westmorland, the underlying audit could not be found for one of the missing years and for Loyalton, the city did not report its pension liabilities and assets for 2013-2015 because of a lawsuit with employees.*
We also see that a large gap has opened up between pension liabilities and pension assets, meaning that cities now have sizable unfunded pensions that are significantly larger than their bond debt. In 2008, pension liabilities and pension assets averaged 149% and 139% of revenue respectively. This means that unfunded pensions were quite small at only 10% of revenue and were smaller than bonds outstanding, which averaged 19% of revenue. However, because the pension fund is invested in risky assets, the pension assets dropped during the financial crisis and the safe pension liabilities continued to grow, creating a large gap between the two. While the pension fund has delivered positive returns since 2009, the cumulative return has not caught up to its pre-crisis trend, meaning that pension fund assets are still substantially below the value cities were forecasting in 2008. This persistent gap between pension liabilities and assets means that unfunded pensions from 2009-2015 range from 47-64% of revenue. In short, the cities had a leveraged position in the risky assets because they were issuing safe pension liabilities and backing them by investing in the pension fund. When a negative shock was realized between 2008 and 2009, the safe liabilities quickly outstripped the risky assets.
2.2.2 Cross-section

This leveraged exposure to risk is not constant across cities. Figure 2 shows the cross-section of city finances in 2015, the final year of the panel. The total liabilities will refer to the sum of the pension liabilities and bonds outstanding. There are three important differences to note. First, there is wide variation in the size of city balance sheets, with many cities having both assets and total liabilities below 50% of revenue, while others have assets and total liabilities in excess of 300% revenue. Second, cities differ substantially in their net wealth, which is the value of pension assets minus total liabilities. While wealth as a percent of revenue is -71% on average, this ranges from small, positive values of 2.5% to immense negative values below -300%. These two results both indicate that there are some cities which are at a much higher risk of insolvency than others. Towards the left-side of the graph, there are many cities that have relatively high net wealth and are fairly insulated from any financial shocks because they do not have large assets or total liabilities. Towards the right-side of the graph, we also have many cities with low net wealth that are highly exposed to financial shocks because they have a levered position in the risky assets with large pension assets and large total liabilities.

The third difference to note is that the composition of total liabilities varies substantially across cities. While pension liabilities are on average much higher than bonds outstanding at 217% of revenue compared to only 16.4%, bonds constitute a large portion of total liabilities for some cities. For 20 cities, bonds outstanding are actually larger than pension liabilities. This means that any difference in the treatment of bonds and pension liabilities will matter when assessing which cities are mostly likely to become insolvent. For example, if pension liabilities can be easily renegotiated, then we may not need to worry about cities where total liabilities are predominantly pension liabilities. Section 2.3 directly tests this idea.

2.2.3 Large and small city differences

One of the factors that contributes to the large heterogeneity across cities in their balance sheets is the fact that cities do not all provide the same bundle of services. This means that cities will use a different mix of capital, non-pensioned labor, and pensioned labor. Because cities compete for public employees, there is effectively a market compensation package for each type of employee, with some types receiving large pension benefits while others do not. For example, large cities spend more of their revenue on public safety, which primarily uses pensioned labor in the form of police and firefighters. In comparison, small cities spend more on services such as sewage, which are more capital
intensive and use non-pensioned labor. This means that large cities will tend to have higher pension liabilities relative to revenue than small cities and will have to offset these liabilities by either issuing fewer bonds or saving more in their risky pension funds. This difference will be useful in the quantification exercise of Section 4.

To capture these differences, I separate cities into two groups based on their 2010 Census population. Using the same reports from which the pension assets, pension liabilities, and bonds outstanding are gathered, I measure the payroll for pensioned employees for both groups as well as the expenditure on public safety and public health. Large cities spend 25.0% (0.3%) of revenue on pensioned labor, compared to only 20.6% (0.3%) for small cities. This 4.4 (0.4) percentage point difference is almost exactly explained by differences in public safety and public health expenditures. Large cities spend 4.5 (0.4) percentage points more of revenue on public safety than small cities and 4.5 (0.5) percentage points less of revenue on public health, which is primarily sewage and waste.

2.3 Seniority of pensions

As with any type of liability, the most important first question for pension liabilities is whether they need to be paid. While pension liabilities are much larger than bonds outstanding on average, it is possible that they do not affect the risk of insolvency because they can be easily altered in bad times. I find that pension liabilities are quite difficult to alter and actually appear to be senior to bonds, making them the most immutable liability on the city’s balance sheet. For California in particular, the pension liabilities appear to be virtually non-defaultable with almost no instances of accrued benefits not being fully paid.

To test whether pension liabilities can be easily altered, I collect settlement details for all of the five city bankruptcies across the US since 2008. Because pension liabilities include all accrued benefits, liabilities will still be cut even if a city leaves benefits for current retirees unchanged and simply alters the already accrued benefits for current workers. Cuts to bonds are taken from Moody’s and cuts to pension liabilities are taken from the bankruptcy exit plans. For the five bankruptcies, bonds outstanding were on average cut by 29% while pension liabilities were only cut by 10%. This is despite the fact that bonds outstanding averaged only 70% of revenue while pension liabilities averaged

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9This is likely because there are economics of scale in the sewage system that do not exist for public safety. In small rural cities, the population is widely dispersed, which means the expenditure per person to maintain the sewage system is high. As a city becomes more populated, the expenditure per person falls and sewage becomes a smaller share of overall expenditures, while services that do not benefit from economics of scale will become a larger share.
339%. In other words, cities choose to make larger cuts to bonds even though they could have saved more money by cutting pensions.

In California, the results are even more stark. Over 95% of California city pension plans are run through CalPERS and only one CalPERS city plan has ever failed to fully pay accrued benefits since they began managing city pensions in 1967. This one instance only affected three employees, meaning that pension liabilities have been approximately non-defaultable in California for more than five decades. Interestingly, this is not due to legal protections for the pensions. In multiple cases, judges ruled that California cities could default on accrued benefits, but even cities in bankruptcy still chose to fully pay the pension liabilities. This is discussed more in Section 3.2, but cities have stated that the main reason they do not cut pensions is because public employees may leave the city en masse as punishment.

This seniority of pension benefits means that the pension system affects insolvency risk in two ways. First, cities have large unfunded pensions that will need to be paid. Since the liabilities cannot be easily cut and cities do not have enough money in their pension funds to pay the liabilities, cities will have to divert revenue from services in order to pay off unfunded pension benefits. Second, unfunded pensions will grow (shrink) in recessions (expansions). Cities pay their employees in non-defaultable pension benefits and invest in a risky pension fund to cover these benefits. This acts as a levered investment in risky assets and means that unfunded pensions will rise substantially in recessions, which is exactly when cities have the least amount of revenue to cover these losses.

2.4 Insolvencies and bond spreads

Because pension liabilities are non-defaultable, bond spreads will be a poor measure of fiscal health, although they will still be useful for measuring borrowing costs. This is because spreads depend on the likelihood that a city will default. If a city has little to no bonds outstanding, then there is no reason to default even if a city has large unfunded pensions that it is struggling to pay. The then-mayor of San Diego, Jerry Sanders, stated this idea quite clearly in 2010, writing “In the end, bankruptcy would cost hundreds of millions of dollars and net nothing in return. And the most compelling claim made on its behalf – that it would allow us to shed our pension obligations – is patently false.”

Instead, I will focus on service-level insolvency, where a city is unable to provide essential services for residents, as my measure of fiscal health. This is an unbiased measure, as both bond liabilities and pension liabilities could potentially force city to cut services. It is also more directly tied to household welfare than default risk, as it relates
specifically to the public services provided to residents. To measure these insolvencies, I hand-collect a record of fiscal emergencies in California cities since 2000. In California, tax changes require voter approval and this vote can only be held once every two years. A fiscal emergency is a declaration of insolvency that allows a city to skip this waiting period and hold an immediate vote on taxes. The key requirement is that the city must show that this is necessary to avoid cutting essential services, such as water, sewage, or public safety.

I create this record by contacting the clerk’s office of all 475 cities and running a public records search for declarations of a fiscal emergency. To give a concrete example of a fiscal emergency, I have copied the title section of Resolution No. 2013/33 from the City of Antioch below.

Resolution of the city council of the City of Antioch declaring a Fiscal Emergency; calling for and noticing a municipal election on November 5, 2013 to present to voters a temporary one-half cent transactions and use (sales) tax to fund all essential Antioch city services including police, code enforcement, and economic development.

The key elements are that the city is declaring an emergency in order to hold a vote on temporary taxes to fund essential services. The rest of the resolution then argues why the city’s current state qualifies as service-level insolvent. In this case, the main factors are a 40% reduction in public employees, a 30% increase in violent crime, a 23% increase in property crime, and an increase in response times for priority 1 (life threatening) police calls.

While bond spreads will not be as useful as fiscal emergencies for measuring fiscal health, they are still important for understanding city borrowing costs. A city’s decision to issue bonds will depend heavily on the interest rate it faces. I collect data on all municipal bond trades where customers are buying or selling to a dealer from MSRB for 2008-2015. I then identify the bonds associated with each city using the 6 character issuer CUSIP’s from the Thomson Reuters MuniProfiles database and collect the characteristics for each bond from Bloomberg such as its tax status and whether the bond is insured by a third-party.

### 2.5 Discussion of discount rates

Cities report their liabilities as the present value of benefit payments discounted at the average return on the pension fund. However, since the pension fund earns a risk pre-

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10This data was collected with the assistance of the Shultz Graduate Student Fellowship in Economic Policy.
mium and pension benefits are risk-free, this understates the value of these benefits. As argued by Brown and Wilcox (2009) and Novy-Marx and Rauh (2011a), if pension benefits are safe claims then using a risk-free discount rate is the correct method to measure the present value of benefits. This gives substantially higher values for pension liabilities. For 2015, the liabilities of CalPERS city plans discounted at a risk-free rate of 3.5% were 1.65 times the value discounted at the standard 7.5%.

Another way to view this difference is that cities are not reporting the value of insuring the pension fund against risk. While the reported liabilities state how much the pension fund will need to cover benefits on average, the government is responsible for any losses or gains from the pension fund under- or over-performing. The value of this insurance is precisely the difference between the value of benefits discounted at the average return on the pension fund and the value of benefits discounted at the risk-free rate.

To address this issue, the model uses a stream of benefit payments rather than a present discounted value. I approximate pension benefits as long-term bonds where a constant fraction mature each period following the standard formulation for long-term bonds of Leland (1994), Hatchondo and Martinez (2009), Arellano and Ramanarayanan (2012), and Chatterjee and Eyigungor (2012). The fraction of benefits that mature each period is set to match the duration of pension benefits measured in the data. Since 2013, CalPERS plans have reported their liabilities discounted at a risk-free rate as well as the average return on the fund. The duration is estimated based on how much the present value changes when the discount rate is lowered.

3 Model

To understand how city finances affect insolvency risk, and conversely how the risk of insolvency affects the cities’ financial decisions, I construct a dynamic, small open economy model. The model features two main agents. The first is a government that provides public services to households. The government pays for these services with a combination of wages and pension benefits and places money in a risky pension fund to offset the pension benefits. The government can borrow by issuing municipal bonds or by not fully funding new pension benefits. The government can default on pension benefits or bonds outstanding but at different costs and can declare a fiscal emergency in order to ask households for a transfer. In equilibrium, the cost of defaulting on pensions will be high enough that it never occurs.

The second main agent is households, who have preferences over public services as well as their own consumption. If a fiscal emergency is declared, then households will
choose how much they want to transfer to the government to pay for additional public services. In addition to the two main agents, the model will feature creditors who price all of the assets, including the municipal bonds, and public employees who produce services.

3.1 Endowments, preferences, and assets

Governments

In each city, public services are provided by a local government. Each city government receives an exogenous endowment of tax revenue. The tax revenue is exogenous to capture the fact that California cities cannot independently change taxes. This revenue fluctuates based on i.i.d. aggregate growth shocks as well as an idiosyncratic log AR(1) component. Specifically, the government of city $i$ has revenue

$$Y_{i,t} = \Gamma_t y_{i,t}. \quad (1)$$

The component $\Gamma_t$ is shared across all cities and is subject to growth shocks $g_t$,

$$\Gamma_t = g_t \Gamma_{t-1}. \quad (2)$$

The aggregate growth shocks take three values, $g_t \in \{g^{exp}, g^{rec}, g^{dis}\}$, representing an expansion, recession, or disaster with probabilities $1 - \pi^{rec} - \pi^{dis}$, $\pi^{rec}$, $\pi^{dis}$. Along with the aggregate component $\Gamma_t$, city $i$ revenue has idiosyncratic log AR(1) $y_{i,t}$ with persistence $\rho$ and variance $\sigma^2$. The government has preferences

$$\mathbb{E} \left[ \sum_{t=0}^{\infty} \beta^t u(\bar{S}_{i,t}) \right] \quad (3)$$

where $\bar{S}_{i,t}$ is public services, $u''(S) < 0, \lim_{S \to 0} u'(S) = \infty$, and $\lim_{S \to \infty} u'(S) = 0$.

Households

The households of city $i$ have disposable income

$$Y_{i,t}^h = \Gamma_t y_{i,t}^h \quad (4)$$

which can either be consumed or given to the government to spend on services. Households have preferences over public services $S_{i,t}$ and household consumption $C_{i,t}$ given by

$$\mathbb{E} \left[ \sum_{t=0}^{\infty} \beta^t \left( u(S_{i,t}) + u_c(C_{i,t}) \right) \right]. \quad (5)$$

Footnote: Footnote on government revenue being more volatile than household income in the data.
Households have the same felicity for services as the government \( u (S_{i,t}) \) and their felicity for consumption is concave, \( u''_c (C_{i,t}) < 0 \).

Because households do not experience idiosyncratic shocks to income, they have little reason to borrow or save with other households, as households in all cities have perfectly correlated income. Alternatively, one could imagine that households have idiosyncratic income shocks but have written contracts with the households of other cities to completely insure against these shocks. Even in instances where households give some of their income to the government to spend on services, these transfers are only a small portion of their income, meaning that consumption is almost perfectly correlated across cities. Because of this, I make the simplifying assumption that households do not borrow or save and only make intra-period decisions. Thus, the model can be solved just from their one-period felicity \( u (S_t) + u_c (C_t) \). Their full preferences in equation (5) will only be used to evaluate welfare.

**Creditors**

Each individual city is a small open economy. Outside of the cities is a continuum of competitive creditors with endowment \( \Gamma_t y^m \) that they consume each period. The creditors have preferences

\[
E \left[ \sum_{t=0}^{\infty} \beta^t u_m (\Gamma_t y^m) \right].
\]

Since the creditors price the municipal bonds, it is useful to represent their preferences in terms of their pricing kernel

\[
m_t = \beta^t u'_m (\Gamma_t y^m) u'_m \left( \Gamma_{t-1} y^m \right).
\]

**Assets**

Each government’s portfolio is comprised of three components. The first is pension benefits owed to public employees \( B_{i,t}^p \). These benefits are non-tradable; they are accrued when the government provides services and dispersed when the benefits mature. The cost of services is normalized so that one unit of services costs the government one unit in immediate wages and \( \eta \) units in pension benefits. Each period, a portion \( \lambda \) of these pension benefits mature, meaning that the government has a stream of geometrically decaying payments \( \lambda, (1-\lambda) \lambda, (1-\lambda)^2 \lambda, ... \) for each unit of \( B_{i,t}^p \).

The second component is the pension fund assets \( A_{i,t} \). The government can save in a risky pension fund that has return \( R (\gamma_t) > 0 \) which varies depending on the aggregate shock. For California, 95% of all city pension plans are run through CalPERS, which
invests all city pension funds into a single portfolio that gives the same return to all cities. Even for the cities that do not use CalPERS, their pension funds invest in a similar mix of equity, fixed income, and real assets as CalPERS. To capture this fact, the model return on the pension fund is identical across cities. However, cities can still take on more or less risk through the use of the third component, one-period bonds $B_{i,t}$ which are priced by creditors. By choosing how much to save or borrow in bonds and how much to save in the risky pension fund, cities can control their exposure to the aggregate risk.

### 3.2 Default and insolvency

Each period, the government either pays or defaults on maturing pension benefits and bonds outstanding. If the government does not pay maturing pension benefits $\lambda B_{i,t}^p$, then public employees punish the government by providing zero services. Because $u'(0) = \infty$, this punishment is strong enough that pensions will always be paid. Intuitively, what makes pensions so difficult to default on is the fact that they are debt owed to people that can severely harm the government. This fear of backlash from employees played a large role in recent municipal bankruptcies. While judges ruled that pension benefits could be defaulted on as part of the Stockton and San Bernardino bankruptcies, the Stockton city manager stated that defaulting on the CalPERS pension plan benefits would lead to a “mass exodus” of public employees. Similarly, a disclosure from the San Bernardino bankruptcy states “the City determined that it could not reject its contract with CalPERS. The City concluded that rejection of the CalPERS contract would lead to an exodus of City employees.”

If the government defaults on bonds $B_{i,t}$, then the creditors and the city go to court and a bankruptcy judge will force the city to pay a default cost of $\phi (g_{i,t}) Y_{i,t}$ to creditors. The default cost can vary with the aggregate state to allow for the possibility that default may be easier in bad aggregate states, particularly in disasters. For example, during the Great Depression, Congress passed laws making municipal bankruptcy and default substantially easier. While many sovereign default models also include a period of exclusion from credit markets as part of the punishment for default, I do not assume that cities are excluded after default. This is done to allow for the possibility that cities pay the default cost on their current bonds outstanding partly through issuing new bonds as often occurs in city bankruptcies. The lack of exclusion is also consistent with creditors

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12Prior to the Great Depression, cities could not legally declare bankruptcy to seek protection from creditors. In 1934, at the height of the Great Depression, Congress created the Chapter 9 bankruptcy code for municipalities, which was subsequently followed by the largest series of municipal defaults in US history.
being competitive. If creditors attempt to collude and refuse to buy a city’s new bonds after default, some creditors will always deviate and buy the bonds at a low price. This would continue until enough creditors deviate that the bonds are competitively priced.

Given that payment $\phi(g_i) Y_{i,t}$ to creditors is the only punishment, default on bonds will occur whenever $B_{i,t} > \phi(g_i Y_{i,t})$, i.e. the cost of paying the bonds exceeds the default cost.

Lastly, the government can declare insolvency each period. To match how insolvency is measured in the data, model insolvency is defined as the government declaring a fiscal emergency (FE) in order to ask households for a transfer. Let $\delta_i$ be 1 if a fiscal emergency is declared and 0 otherwise, and let $S^g_{i,t}$ denote the amount that the government spends on services. If a FE is not declared, then public services and household consumption are simply $S^g_{i,t}$ and $Y^h_{i,t}$. If a FE is declared, then households choose an amount to transfer $S^h_{i,t} \geq 0$ which will be taken from their consumption and spent on services. Formally, we have

$$S_{i,t} = S^g_{i,t} + \delta_i S^h_{i,t}$$
$$C_{i,t} = Y^h_{i,t} - \delta_i S^h_{i,t}.$$ 

This is designed to capture the fact that during real-world fiscal emergencies, households are voting on a temporary tax increase to fund public services. The model households are providing the government with a temporary transfer to increase services.

### 3.3 Decision problems

I focus on the Markov Perfect Equilibrium (MPE) of a sequential stage game between households, creditors, and government. That is, I assume that agents act sequentially, cannot commit to future decisions, and make their decisions based only on payoff-relevant state variables. From here forward, I drop the $i$ and $t$ subscripts. The timing of the model is the following: at the beginning of each period, the exogenous states $\Gamma, g, y$ are realized and bonds are defaulted on if $B > \phi(g) Y$. The city government then chooses whether to declare a fiscal emergency $\delta$, government spending on services $S^g$, and their next period portfolio $(A', B', B')$. Given these choices, creditors choose the bond price $q$. Lastly, if a fiscal emergency was declared, households choose a transfer $S^h$.

#### Household and creditor decisions

In the third stage, households choose a transfer $S^h$ if a fiscal emergency was declared by the city government. Given the aggregate state $\Gamma$ and the government’s spending on services $S^g$, households choose $S^h \geq 0$ to maximize their utility subject to equations...
This gives that the optimal transfer will balance their marginal utility of services and their marginal utility of consumption, subject to the constraint that transfers must be positive. Specifically, the transfer will be

\[ S^h(S^g, \Gamma) = \begin{cases} 
  z : u'(S^g + z) = u'_c(Y^h - z) & \text{if } u'(S^g) > u'_c(Y^h) \\
  0 & \text{otherwise.}
\end{cases} \tag{10} \]

The assumptions on \( u(\cdot), u_c(\cdot) \) guarantee that \( S^h(S^g, \Gamma) \) exists, is unique, and is the optimal transfer. They also guarantee that transfers are weakly decreasing in \( S^g \) and weakly increasing in \( \Gamma \).

In the second stage, creditors set the bond price. There are a continuum of competitive creditors, so the price of the bonds must equal the discounted value of the future payments,

\[ q(B', \Gamma, y) = E[m(\Gamma', g')] - E[m(\Gamma', g') \left( 1 - \frac{\phi(g') \Gamma' y'}{B'} \right) \mathbb{1} \{ B' > \phi(g') Y' \}] \tag{11} \]

where the pricing kernel if given by equation (7).

**Government decisions**

In the first stage, the government enters the period with exogenous states \((\Gamma, y, g)\) and portfolio \((A, B, B_p)\). After paying maturing pension benefits and either paying or defaulting on bonds, the government has cash-on-hand

\[ X = Y - \lambda B_p - \min \{ B, \phi(g) Y \} + R(g) A \tag{12} \]

and non-tradable pension benefits \((1 - \lambda) B_p\). Given the bond price function of creditors \( q(B', \Gamma, y) \) and the transfer function of households \( S^h(S^g, \Gamma) \), the government’s problem is

\[ V(X, B^p, \Gamma, y) = \max_{S, S^g, \delta, A', B', B_p} u(S) + \beta E[V(X', B'^p, \Gamma', y')] \tag{13} \]

\[ S^g = X - A' + q(B', \Gamma, y) B' \]

\[ S = S^g + \delta S^h(S^g, \Gamma) \]

\[ A' \geq 0 \]

\[ B'^p = (1 - \lambda) B^p + \eta S. \]

In instances where the government is indifferent between declaring and not declaring a FE, I assume that it does not declare an FE. This is akin to the standard assumption in sovereign default models that the government does not default when indifferent between defaulting and not defaulting. We can simply the problem by noting that \( \delta = 1 \) iff \( S^h(S^g, \Gamma) > 0 \). This is shown formally in the Appendix. The intuition is that because
the government only cares about services, it will always accept any transfers that the households are willing to offer. This also maps nicely to the real world, where a fiscal emergency is only declared if money is needed for “essential services.” In the model, the level of essential services will be the threshold for \( S^g \) such that the transfer function is positive. Given this decision for \( \delta \), the government only has to choose \( S^g \) and its next period portfolio \((A', B', B'^p)\).

### 3.4 Equilibrium

A Markov-Perfect Equilibrium is a set of a value function \( V \), policy functions \( \{S, S^g, A', B', B'^p\} \), a bond price function \( q \), and a transfer function \( S^h \) such that

1. Taking as given the bond price function \( q \) and transfer function \( S^h \), the policy functions \( \{S, S^g, A', B', B'^p\} \) and the value function \( V \) solve the government’s problem \((13)\).

2. The bond price function \( q \) satisfies \((11)\).

3. The transfer function \( S^h \) satisfies \((10)\).

### 4 Quantification

The main friction in the model is that when the government is poor, it will overspend and take on excessive risk relative to what households would want the government to choose. To quantify the magnitude of this overspending and excess risk-taking, I study the response of cities after becoming unexpectedly poorer during 2008-2010 and compare the responses of cities that were more or less exposed to this shock. As shown in Figure 1, pension fund assets drop after 2008 while pension liabilities continue to grow, meaning that the net wealth of cities declines substantially. As shown in Figure 2 and detailed in Section 2.2.3, this did not affect all cities equally. Cities with large populations tend to have bigger pension systems relative to revenue due to the fact that they spend more on services that require pensioned labor. Thus, large cities will tend to be more affected by the increase in unfunded pensions. Based on the response of large and small cities to this shock, I infer the key model parameters that control overspending and excess risk. Cities are split into two bins based on populations, with 237 cities and 238 cities in the small and large bins respectively.

In this section, I first discuss the functional forms used for preferences and default costs, and then estimate the exogenous revenue and return processes. I find that idiosyncratic shocks have higher volatility in small cities, but otherwise their exogenous
processes are quite similar. I then estimate the 8 model parameters to match 33 moments from the empirical response of cities to the financial crisis and give a detailed analysis of city savings, exposure to risk, and fiscal emergencies. The model correctly predicts that large cities will be more likely than small cities to declare a fiscal emergency after 2010, even though small cities are more prone to big negative idiosyncratic shocks, and that within each group, cities with higher pension assets relative to revenue in 2008 will be more likely to declare a fiscal emergency. In other words, exposure to the decline in pension fund assets and the increase in pension liabilities significantly raises the probability of a city declaring insolvency after the crisis. Lastly, I discuss how the model matches both the low number of observed defaults and the high spread on bonds without requiring high creditor risk aversion.

4.1 Functional forms

All agents have CRRA preferences. The government and households have risk aversion $\gamma$ for services, $S^{1-\gamma}/(1-\gamma)$. Households have the same risk aversion for consumption and a scaling factor $\psi$, $\psi C^{1-\gamma}/(1-\gamma)$. Creditors have risk aversion $\gamma_m$ and discount factor $\beta_m$. The creditors’ discount factor is set to match a nominal risk-free rate of $R_f = 1.04$ and their risk aversion is set so that creditors price the risky asset.

In the model, the cost of services is normalized so that one unit of services costs 1 unit in current cash and $\eta$ units in pension benefits. Because the cash cost of services is normalized to 1 rather than the full cash and pension cost, this normalization will make services cheaper in small cities, where $\eta$ is lower. The full cost of a unit of services is $1 + \frac{\lambda}{r_f+\lambda} \eta$, where the second term represents the value of the risk-free pension benefits being paid to employees with $r_f \equiv R_f - 1$. To account for this normalization, I also normalize the value of $\psi$ in both groups of cities,

$$\psi_i = \tilde{\psi} \left(1 + \frac{\lambda}{r_f+\lambda} \eta_i\right)^{-1} \quad (14)$$

where $i = \text{small, large}$ and $\tilde{\psi}$ will be an estimated parameter.

Lastly, I set the default cost so that $\phi (g^{exp}) = \phi (g^{rec})$. The default cost will only differ in the disaster state. In the data, there was not a large increase in defaults during the 2008-2010 recession. Most of the recent defaults occurred after the recession had ended. The only period where municipal defaults dramatically increased was the last disaster, the Great Depression.
Table 1: Revenue process parameters

<table>
<thead>
<tr>
<th>$g^{exp}$</th>
<th>$g^{rec}$</th>
<th>$\rho$</th>
<th>$\sigma_{large}$</th>
<th>$\sigma_{small}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.048</td>
<td>0.944</td>
<td>0.375</td>
<td>0.112</td>
<td>0.177</td>
</tr>
<tr>
<td>(0.002)</td>
<td>(0.004)</td>
<td>(0.012)</td>
<td>(0.004)</td>
<td>(0.007)</td>
</tr>
</tbody>
</table>

4.2 Exogenous processes

To estimate the revenue process for small and large cities, I use a longer panel of revenue that covers 453 cities from 2003-2015. I set 2009 and 2010 as the recession years since average revenue for both groups fell in these years and set all other years as expansion years. The values for $g^{exp}, g^{rec}, \rho$ are estimated from the following pooled regression

$$
\log(Y_{i,t}) = \alpha_i + \rho \log(Y_{i,t-1}) + (1-\rho) \log(g^{exp}) t + (\log(g^{rec}) - \log(g^{exp})) [1\{t \geq 2009\} + (1-\rho) 1\{t \geq 2010\} - \rho 1\{t \geq 2011\}] + \epsilon_{i,t}
$$

where $\alpha_i$ is a city fixed-effect. The regression can be estimated separately for large and small cities, but the estimated values of $g^{exp}, g^{rec}, \rho$ only slightly differ between the groups. The Appendix gives more detail on the separate regressions. Where large and small cities do differ is in the volatility of their idiosyncratic shocks, $\sigma$, which is estimated from the residuals of the regression. Table 1 gives the estimated parameters for the revenue process.

The remaining parameters for exogenous processes are the returns, the disaster parameters, the probabilities of the aggregate states, and the maturity probability for pension benefits. Since almost all plans are run through CalPERS, I estimate the returns in expansions and recessions from the CalPERS return for 2003 to 2015, which gives $R(g^{exp}) = 1.100$ and $R(g^{rec}) = 0.928$. The parameters for the disaster state are taken from Barro (2006). To show that the model can generate large spreads and support a high equity premium without needing large disasters, I use conservative estimates for $g^{dis}, R(g^{dis}), \pi^{dis}$ of 0.85, 0.85, 0.015. The probability of recession $\pi^{rec}$ is estimated from the NBER recession series using all post-1945 observations. Controlling for the fact that the 1.5% chance of disaster is not realized over this period, the probability of recession is 0.143. Finally, $\lambda$ is set to 0.025 to match a duration of 13 years when moving from the risk-free rate to the discount rate used by city actuaries of 7.5%.\[13\]

\[13\]Specifically, I set $\lambda$ so that $r_p - \lambda = \left(\frac{1+r_p}{1+r_f}\right)^{13}$ where the LHS is the ratio of the discounted value at the risk-free rate to the discounted value at the rate used by actuaries $r_p = 0.075$. 

25
### Table 2: Estimated parameters

<table>
<thead>
<tr>
<th>$\beta$</th>
<th>$\gamma$</th>
<th>$\bar{\psi}$</th>
<th>$y^h$</th>
<th>$\phi (\sim g_{\text{dis}})$</th>
<th>$\phi (g_{\text{dis}})$</th>
<th>$\eta_{\text{large}}$</th>
<th>$\eta_{\text{small}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.95</td>
<td>6.61</td>
<td>16.72</td>
<td>1.46</td>
<td>2.17</td>
<td>0.16</td>
<td>0.25</td>
<td>0.17</td>
</tr>
</tbody>
</table>

### 4.3 Parameters and moments

The eight model parameters will be the preference parameters $\beta$, $\gamma$, $\bar{\psi}$, the level of household disposable income that households can give to the government $y^h$, the default costs $\phi (\sim g_{\text{dis}})$, $\phi (g_{\text{dis}})$, and the accrual rate for pension benefits for large and small cities $\eta_{\text{large}}$, $\eta_{\text{small}}$. Table 2 shows the estimated values. These parameters are estimated to match six time series, the number of defaulting cities, the number of cities with fiscal emergencies, and the average bond spread for 2010-2015. The six time series are the average net wealth, risky assets, and pension liabilities, all relative to revenue, for small and large cities.

Given a set of parameters, I use the following method to estimate the model response to the financial crisis. First, I solve the model described in Section 3 for both large and small cities to get the policy functions for the government, the bond price function, and the transfer function. Second, I use the estimated shock process and the realized revenue to infer the realized exogenous shocks $g_t$, $\Gamma_t$, and $y_{i,t}$. Last, I set each city’s initial state variables to their 2010 measured values and then feed in the realized exogenous shocks to calculate the model government’s choice of next period pension assets, pension liabilities, and bonds, as well as the bond price (if any bonds are issued) and whether a fiscal emergency is declared.

In the data, the pension liabilities are measured as the present value of benefits discounted at $r_p = 7.5\%$ and the net wealth is the value of pension assets minus pension liabilities and bonds outstanding. Thus, the model equivalent of these variables will be

$$L = \frac{\lambda}{r_p + \lambda} B^p,$$

$$W = A - L - B.$$  

The number of defaulting cities for 2010-2015 in the data is 2 (San Bernardino and Stockton), the number of cities with fiscal emergencies is 57, and the targeted spread on bonds is 1.08%. Table 3 and Figure 3 summarize the fit of the estimated model. While the model and the data have the same average pension fund return in expansions, the data realizations for returns fluctuate each year while the model returns for 2011-2015 are always $R (g^{\exp})$. This is why the paths for wealth and pension assets are more volatile in the data than in the model.
While all 8 parameters are estimated jointly, the discount factor $\beta$ and the risk aversion $\gamma$ are primarily determined by the paths for wealth and risky assets, respectively, across both groups of cities. A higher discount factor will cause cities to save more and a higher risk aversion will lower their desire to hold risky assets. The values for $\bar{\psi}$, $y^h$ are controlled by the difference between small and large cities in wealth and risky assets, as well as the number of fiscal emergencies, since these parameters control the transfer function. As we will see in Section 4.5, large cities are more likely to declare a fiscal emergency over this period and therefore their choices for wealth and risky assets are more sensitive to changes in the transfer function than the choices of small cities. A lower value of $y^h$ or a higher value of $\bar{\psi}$ will cause large cities to increase wealth and hold less risky assets, relative to small cities, since they cannot rely on households to provide large transfers if there are bad future shocks. The Appendix details how the choice of wealth will be primarily dictated by $y^h$ while the choice of risky assets will mainly depend on $\bar{\psi}$. The values for $\eta_{\text{large}}, \eta_{\text{small}}$ are determined by the paths of liabilities for the two groups and the default costs $\phi(\sim \delta^{\text{dis}}), \phi(\delta^{\text{dis}})$ primarily depend on the number of defaults and the average bond spread.
4.4 Response of savings and risk exposure

Given that overspending and excess risk are the main inefficiencies in the model, the key variables of interest will be the wealth and risk exposure of cities. To make comparison across groups and time easier, Figure 4 shows the change in W/Y and A/Y since 2010. As seen in both Figures 3 and 4, cities have gradually increased wealth since 2010, but even after five years of aggregate expansion shocks, cities have only undone about 1/4 of the loss in wealth from 2008-2010. For small and large cities, wealth-to-revenue declined 45pp and 63pp respectively from 2008 to 2010 and has only increased 9pp and 17pp from 2010 to 2015. Over this same time, exposure to risk has increased for both groups. Pension assets-to-revenue have increased 26pp and 34pp for small and large cities. The fact that risky assets have increased more than net wealth means that cities also have bigger balance sheets, i.e. the increase in assets is offset by an increase in bond and pension liabilities.

Comparing across groups, large cities have a bigger decline in wealth from 2008-2010. This is because they tend to run larger pension systems and were more affected when pension assets declined while pension liabilities continued to grow. In response, large cities increase wealth 8pp more than small cities from 2010-2015, but they do not do this by issuing fewer bonds or accumulating fewer pension liabilities. As shown in the right-hand side of Figure 4, this is entirely done by increasing pension fund assets 8pp more than small cities.\textsuperscript{14} Thus, across time and across groups, cities are slowly reversing the wealth decline from the financial crisis, primarily by investing more in their risky pension funds.

4.5 Response of fiscal emergencies

After the 2008-2010 shock, the number of cities declaring fiscal emergencies increases dramatically. For 2000-2007, only 14 cities declare a fiscal emergency. For 2010-2015, more than four times as many cities, 57, declare a fiscal emergency. What is not obvious beforehand is which types of cities will declare fiscal emergencies. Large cities run bigger pension systems and were more exposed to pension fund losses during the crisis. However, large cities also have more stable revenues ($\sigma_{\text{large}} = 0.112$, $\sigma_{\text{small}} = 0.177$), meaning they may be able to spread these losses over time to avoid any major service reductions. In comparison, small cities may be forced into a fiscal emergency due to

\textsuperscript{14}This is not explained by large cities simply earning more on their pension fund assets. In both the model and the data, the pension fund earns higher than average returns for 2010-2015 due to consistent aggregate expansion shocks. However, this only accounts for 2.7pp of the 8pp difference. The primary source of the difference is that large cities are putting more money into their funds.
large negative idiosyncratic shocks.

As shown in Table 4, the model correctly predicts that large cities while be more prone to fiscal emergencies over this period. In the model, 39 of the 57 cities with fiscal emergencies are large, compared to 34 in the data, meaning that exposure to pension fund losses dominates the differences in revenue volatility. We also see that within each group, cities with larger pension fund assets relative to revenue in 2008 were more likely to declare a fiscal emergency. Table 5 shows the results of a simple regression of whether a city declared a fiscal emergency in 2010-2015 on the city’s 2008 pension assets-to-revenue, controlling for city group. In both the model and the data, an increase in 2008 pension assets-to-revenue significantly increases the probability of a city declaring a fiscal emergency. In other words, we can directly observe that cities with higher exposure to pension fund losses were more likely to become insolvent.

4.6 Defaults and bond spreads

As documented in the literature on municipal bonds, the frequency of default for municipal bonds is quite low outside of the Great Depression, yet these bonds still carry large default risk premia. I calculate the bond spread using the yield for all trades on
Table 5: Regression of FE on risk exposure

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008 Assets</td>
<td>0.045</td>
<td>0.154</td>
</tr>
<tr>
<td>Rev</td>
<td>(0.017)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>1 \text{Large city}</td>
<td>0.025</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
<td>(0.024)</td>
</tr>
</tbody>
</table>

non-insured, tax-exempt bonds for the 475 cities over 2010-2015. Specifically, I measure the tax-adjusted spread as \( \frac{\text{yield}_{i,t}}{(1 - \tau_t) - r_f^t} \), where \( \tau_t \) is the marginal tax rate at time \( t \) and \( r_f^t \) is the risk-free rate at time \( t \) measured from the daily Treasury yield curve. I calculate the marginal tax rate for creditors using the top CA state income tax bracket and the top federal income tax bracket in each year. Since my model uses one-year bonds, I use all trades for bonds with maturity of 9-15 months and estimate an average tax-adjusted spread of 1.46% (0.06%).

As argued in Stock (1994), Liu et al. (2003), and Schwert (2017), this spread can be primarily explained by default risk premia. Schwert (2017) estimates that 74% of the tax-adjusted spread is due to default risk premia. Since spreads in my model are solely due to default risk, I target a model spread of \( 0.74 \times 1.46\% = 1.08\% \).

To match the low number of defaults for 2010-2015 and the high default risk premia, the model gives a high value for the default cost outside of disasters and a low value in disasters. Because creditors price the risky asset, the high spread cannot be due to creditors having extremely high risk aversion. In other words, the risk aversion required to generate this spread with few defaults in all states would not be consistent with the equity premium, since the pension fund is mainly equity. Therefore, the spread must be due to a small chance that many cities will simultaneously default if a disaster is realized, similar to the large series of defaults seen after the Great Depression. This effectively makes the municipal bonds state-contingent contracts, where the cities will almost always pay the full amount \( B \) in non-disaster states, but may pay a lower amount \( \phi \left( S^{\text{dis}} \right) Y \) if a disaster is realized.

\(^{15}\)For robustness I test the effects of using higher creditor risk aversion and introducing bankruptcy inefficiency where creditors do not receive the full default cost that is paid by the city. In equilibrium, high creditor risk aversion tends to lead to lower average spreads, as cities choose to issue fewer or no bonds. Because cities are relatively patient (\( \beta R^f = 0.99 \)), they will not borrow if the high spreads are mainly due to disagreement between creditors and cities about the risk-neutral probability of future states. Similarly, large bankruptcy inefficiency also leads cities to simply not issue bonds and contradicts the high recovery rate for municipal bonds seen in the data.

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5 Results

Using the calibrated model, I study the risk of future insolvencies and how government policies can be changed to increase household welfare. First, I test how many cities would declare insolvency if another stock market bust occurred and find that many cities are unprepared for this negative shock. I then calculate the spending and risky assets that households would choose if they were running the government and how average city wealth $W/Y$ and risky assets $A/Y$ would have changed from 2010 to 2015 under the households’ choices. Motivated by the fact that households choose lower spending and save more in bonds, I analyze two policy experiments: (i) placing limits on spending and (ii) requiring the pension fund to invest more in risk-free bonds. Limits on spending can produce large welfare gains for households while a more bond-heavy pension fund actually produces welfare losses because it reduces the government’s incentive to save.

5.1 Stock market bust

Since 2009, pension funds have consistently delivered positive returns, and stocks in general have experienced a persistent bull market. However, it is unlikely that this will continue forever, which begs the question of how well cities can handle another negative shock to pension fund assets. To answer this, I estimate the effect of a -24% shock to pension fund assets, consistent with the net effect of the 2008-2010 shock. I initialize each city to its 2015 empirical state variables, reduce pension fund assets by 24%, and then simulate 10,000 paths for the future exogenous shocks $g_t, y_{i,t}$ that cities receives. For each path, I calculate the number of cities that declare a FE and then average across paths.

Given the recent financial crisis, one might expect that cities would alter their savings and risk exposure to better prepare for negative shocks in the future. However, I find that the hypothetical 2015 shock causes more than twice as many cities to declare a FE as the original 2008-2010 shock. On average, 143 cities declare a FE in the first six years after the 2015 shock, which is over 30% of all cities. For comparison, in both the model and the data, 57 cities declare a FE in the first six years after the 2008-2010 shock.

Looking at Figures 3 and 4, we can see the reason why. For both large and small cities, net wealth is substantially lower in 2015 than in 2008. As discussed in Section 4.4, cities have only undone about 1/4 of the 2008-2010 decline in wealth-to-revenue. This means that the 2015 shock hits cities that are starting much closer to the insolvency region than the 2008 cities. On top of this, pension fund assets relative to revenue are higher in 2015 than in 2008 for both groups, meaning that the same percent loss on the
pension fund will have a larger impact on the city’s balance sheet. In short, cities are poorer and more exposed to risk in 2015 than 2008.

While the data on individual city pension systems is limited to 2015, I can show that continued positive returns on the pension fund for 2016-2019 will not reverse this result. I consider a simple scenario where no new pension benefits are accrued and no money is added to the pension fund after 2015. The pension fund simply earns the observed CalPERS return $r_t$ for 2016-2019 and maturing benefits are paid with money from the fund. Let $B^p_t, A^p_t, L_i$ denote the pension benefits, pension fund assets, and pension liabilities in this scenario. The benefits and assets follow $B^p_{i,t+1} = (1 - \lambda) B^p_{i,t}$ and $A^p_{i,t+1} = (1 + r_t) A^p_{i,t} - \lambda B^p_{i,t}$. Using equation (15) to substitute benefits for liabilities, we can derive the following, \[
L_{i,t+1} - A^p_{i,t+1} = (L_{i,t} - A_{i,t}) (1 + r^p) + (r^p - r_t) A^p_{i,t}.
\]

In words, this says that unfunded pensions $L_{i,t} - A_{i,t}$ will grow by $r^p = 7.5\%$ each year and will only decrease if the pension fund return $r_t$ exceeds the discount rate for the liabilities $r^p$. For 2016-2019, the annualized return on the pension fund was 6.7\%, which means that unfunded pensions will actually be higher in 2019 than 2015, unless cities specifically act to put more money into the funds. So, recent returns on the pension fund are not enough to increase city wealth and move cities away from the insolvency region.

### 5.2 Household choices for government policy

Given the high risk of future insolvencies, a natural question is whether this is optimal for households. To test this, I calculate the choices for spending and risky assets $(S^g, A')$ that households would choose for the government. This represents a constrained optimum, where households are still restricted by the fact that they cannot commit to repay bonds or to not provide transfers. To get a sense of how much these differences in policy functions matter, I calculate the response of wealth and risky assets under the household policy functions to the sudden decrease in wealth in 2008-2010 and compare this to the actual response. I then measure the welfare gains for households from switching from the government’s choice of policy functions to the household’s choice.

#### 5.2.1 Policy functions

Figure 5 shows the spending and risky assets chosen by the government and the values that households would choose. Both graphs show the policies as functions of cash on hand $X$ for a fixed $(B^p, \Gamma, y)$. On the left-hand side, we see that households’ choice of
spending increases continuously with cash on hand. Due to the inability to commit to repaying bonds, borrowing is limited and spending declines rapidly as cash on hand decreases. In comparison, the government’s choice of spending jumps discontinuously. The dashed line denotes the value for cash on hand were the government switches from declaring to not declaring a FE, which is exactly when the jump in spending occurs.

When $X$ is above this threshold, the government is not currently in a FE, but it knows that it can declare an FE in the future if negative shocks push $X'$ below the threshold. This reduces the government’s desire to save relative to households, so the government spends more than households would choose. As $X$ decreases and approaches the FE threshold, the gap between household and government choices for spending increases, as the likelihood of a FE in the future becomes higher. In other words, overspending is worse when the government is near insolvency. As cash on hand increases, the government and household choices for $S^g$ converge.

Conversely, when $X$ is below the threshold, the government is currently receiving transfers from households and knows that it may not receive transfers next period if positive shocks push $X'$ above the threshold. This incentivizes the government to spend less than households would choose. In general, overspending will be more important than underspending since cities spend the majority of their time above the threshold, i.e. not in a FE.

The right-hand side of Figure 5 shows the choice of risky assets $A'$. While the government has an incentive to over-invest in risky assets, particularly when close to the FE
threshold, it is limited by the fact that it can only borrow at high spreads. This means that at low $X$, when both households and the government are choosing to borrow with bonds, they choose similar values for $A'$. The largest differences between government and household choices for $A'$ occur at high values for cash on hand, where households would choose to save in both bonds and risky assets, while the government chooses to continue borrowing in bonds and saving solely in risky assets.

Figure 6 shows the response of wealth and risky assets under the household policy functions to the sudden decrease in wealth in 2008-2010. The solid lines show the actual response of wealth-to-revenue and assets-to-revenue in the data and the dashed lines show the hypothetical response if households choose spending and risky assets. The largest difference is that households save substantially more. While large and small cities increase wealth-to-revenue by 17pp and 9pp respectively in the data, households increase wealth-to-revenue for the two groups by 58pp and 48pp. This is enough to more than offset the 2008-2010 decline for small cities and almost completely offset the decline for large cities.

Comparing across groups, households increase wealth-to-revenue more for large cities than small cities, but not by saving more in risky assets. In the data, large cities increase wealth-to-revenue 8pp more than small cities by increasing assets-to-revenue 8pp more. Households instead choose for both groups to increase assets-to-revenue by the same amount and have large cities increase wealth more by issuing 10pp fewer bonds. In contrast to raising assets, issuing fewer bonds reduces large cities’ leveraged exposure.
to risk.

5.2.2 Welfare gains

The first three columns of Table 6 show the welfare gains from switching to this constrained optimum assuming each city starts at its 2010 empirical state variables. The constrained optimum produces sizable welfare gains both as a percent of lifetime consumption and as a percent of lifetime services, averaging 0.85% and 2.10% respectively. This is surprising given that changes in the policy functions do not have any first-order effects. They only alter the choice about spending now versus later and the choice of risk exposure.

The reason the welfare gains are not trivial is because the policy functions of the government ensure that cities that start near the FE region will consistently remain near the FE region. As shown in Figure 5, cities near the FE threshold underspend when in a FE and overspend when not in a FE. This produces excess volatility in services compared to what households would choose. It also means that cities currently near the FE threshold will continue to be near the threshold in the future, as they save less when \( X \) is above the threshold and save more when current \( X \) is below the threshold. Thus, these cities will continue to have excessively volatile spending that is too high after good shocks and too low after bad shocks.

As a concrete example, Figure 6 shows that after the 2008-2010 shock to wealth, cities only slightly increased wealth-to-revenue. Because of this, many cities are still quite close to the FE region and will cut services enough that households will provide transfers if another negative shock occurs, as discussed in Section 5.1. In comparison, households would choose to increase wealth-to-revenue considerably more and would be better prepared for a future negative shock. In other words, the governments are spending more during the positive expansion shocks of 2011-2015 and will have to spend less if negative shocks are realized, while households would choose spending that is less volatile across shock realizations.

Comparing across groups, the welfare gains are higher for large cities. In large cities, the cost of services is more backloaded, since services require a higher amount of long-lived pension benefits. This means that saving is more important for large cities and any issues with overspending will be amplified. Similarly, because large cities have more safe pension liabilities, it is easier for them to have levered risk exposure. While households would choose to offset these additional safe pension liabilities by issuing fewer bonds, the government can choose to hold more risky assets instead. In comparison, small cities can only achieve the same levered risk exposure by issuing more bonds to increase their
Table 6: Welfare gains from changing policy functions

<table>
<thead>
<tr>
<th></th>
<th>Constrained optimum</th>
<th>Uncalibrated cap</th>
<th>Calibrated cap</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large</td>
<td>Small</td>
<td>All</td>
</tr>
<tr>
<td>% Lifetime consumption</td>
<td>0.89</td>
<td>0.82</td>
<td>0.85</td>
</tr>
<tr>
<td>% Lifetime services</td>
<td>2.18</td>
<td>2.02</td>
<td>2.10</td>
</tr>
</tbody>
</table>

risky assets, which is discouraged by the high spread on bonds.

5.3 Savings requirements

Given that households would choose to raise wealth-to-revenue more than the government in Figure 6, a natural policy experiment is a state law imposing savings requirements. For the model, this is equivalent to a spending cap. I use the level of essential services as part of the cap. In the real world, this is the threshold for services that determines if a city can legally declare a fiscal emergency. In the model, this will be \( \theta \equiv \psi^{-1/\gamma}y^h \), where cities declare a FE if and only if spending falls below this threshold. I consider spending caps of the form

\[
S^g \leq \kappa_1 X + \kappa_2 \theta.
\]

Table 6 shows the results for two spending caps assuming all cities start at their 2010 empirical state variables. The first is uncalibrated and simply uses \( \kappa_1 = E \left[ R^f / g \right] - 1 = 0.012 \) and \( \kappa_2 = 1 \). This says that city spending is limited to the level of essential services plus the interest on cash on hand. The interest is normalized to account for the fact that there is growth in the model. Even this relatively simple policy produces large welfare gains that are more than half of the total welfare gain of moving to the constrained optimum.

To test how close spending caps can get to the constrained optimum, I calibrate \( \kappa_1, \kappa_2 \) to maximize the welfare gain for all cities. This produces a stricter cap of \( \kappa_1 = 0.004, \kappa_2 = 0.998 \), which limits spending to a smaller portion of both cash on hand and the level of essential services than the uncalibrated cap. Since overspending is a bigger problem for large cities, the stricter cap primarily raises the welfare gain for large cities, from 0.49% of lifetime consumption to 0.77%, but small cities still see a noticeable improvement from 0.64% of lifetime consumption to 0.76%. This calibrated cap produces welfare gains of 0.77% of lifetime consumption and 1.90% of lifetime services. This means that households would be willing for the government to throw away almost 2% of its revenue
each year if it also implemented this spending cap. Discounting those future revenues at $R_f = 1.04$, this would be over $136$ billion.

The calibrated spending cap generates over 90% of the welfare gain of giving households full control over spending and risky assets. This means we can get quite close to the constrained optimum just by forcing cities to save more. As shown in Section 5.2.1, the government’s incentives become more skewed as it gets closer to the FE region. This creates a vicious cycle, where overspending is worse when the government is poor, which in turn increases the chance that the government will remain poor in the future. Implementing spending caps reverses this cycle, as cities are forced to save more, which moves them away from the FE region. As the likelihood of a FE in the future becomes smaller, the government’s incentives align more closely to those of the households and any inefficiencies become smaller. Quantitatively, these benefits outweigh the fact that spending will be low as cities transition from their 2015 state variables to higher levels of wealth and cash on hand and that the spending cap will reduce flexibility in the government’s choice of spending.

5.4 Safer pension fund

Since the two inefficiencies are overspending and excess risk-taking, the second logical policy experiment is to reduce the risk of the pension fund assets. In Section 5.1, we see that many cities would become insolvent if the pension fund experienced a large negative shock. In this section, I test whether household welfare can be improved by forcing the pension fund to invest more in risk-free bonds to prevent these types of large losses. Specifically, I change the pension fund return from its current value of $R(g)$ to

$$\tilde{R}(g) = \alpha R_f + (1 - \alpha) R(g),$$

where $\alpha$ is the weight on risk-free bonds. Since cities can only issue defaultable bonds that have large spreads, they cannot simply undo this change by issuing their own risk-free bonds and putting more money into the fund.

From Figure 6, we know that households primarily want to reduce leveraged exposure to risk for large cities. Households raise wealth-to-revenue more over 2010-2015 for large cities than small cities and do this by issuing fewer bonds, not by holding more risky assets. Figure 7 shows the change in household welfare as a percent of lifetime consumption for large cities for different levels of $\alpha$. Surprisingly, there are no levels of $\alpha$ that produce non-trivial welfare gains and many values produce sizable welfare losses. This is also true for small cities.

Starting with the positive values of $\alpha$, we see that making the pension fund safer
Figure 7: Welfare gain from changing pension fund risk

![Graph showing welfare gain from changing pension fund risk.](image)

actually reduces welfare. This is because it discourages cities from saving due to the lower average return. In other words, the benefits of reducing excess risk-taking are quantitatively dominated by the fact that this worsens overspending. As \( \alpha \) increases, the welfare losses increase from 0.03\% of lifetime consumption at \( \alpha = 0.1 \) to 0.39\% at the completely risk-free pension fund \( \alpha = 1 \).

Given that increasing \( \alpha \) reduces welfare by worsening the problem of overspending, we may actually want to decrease \( \alpha \) to induce cities to save more. In the real world, pension funds invest roughly 20\% into bonds, so one can think of \( \alpha = -0.2 \) as a policy where the pension fund sells all of its bonds and invests purely in the risky portions of the fund. Values of \( \alpha \) below \(-0.2 \) would correspond to the pension fund buying call options on stocks or taking other measures to increase exposure to excess returns. The left portion of Figure 7 shows that as we decrease \( \alpha \) below 0, we do get welfare increases and the slope with respect to \( \alpha \) is initially quite similar to the slope for positive \( \alpha \). However, as we continue decreasing \( \alpha \), the welfare gain levels off and begins falling as excess risk-taking becomes a larger problem. This means that the welfare gains are limited to small values of less than 0.04\% lifetime consumption.
References


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