The Revenue Demands of Public Employee Pension Promises*

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Abstract

We calculate increases in contributions required to achieve full funding of state and local pension systems in the U.S. over 30 years. Without policy changes, contributions would have to increase by 2.5 times, reaching 14.1% of the total own-revenue generated by state and local governments. This represents a tax increase of $1,385 per household per year, around half of which goes to pay down legacy liabilities while half funds the cost of new promises. We examine sensitivity to asset return assumptions, wage correlations, the treatment of workers not currently in Social Security, and endogenous geographical shifts in the tax base.

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The condition of state and local government defined benefit (DB) pension systems in the U.S. has received national attention in debates over government budgets. The academic literature on this issue has primarily focused on three main questions. First, analyses of the strength of the legal claims of public pension beneficiaries have informed studies of the measurement of liabilities under appropriate discount rates (see Gold 2002; Novy-Marx and Rauh 2008, 2009, 2011a, 2011b; Brown and Wilcox 2009). These papers have largely focused on already-accrued liabilities. Second, several papers have considered the optimal level of funding for public employee pension plans (D'Arcy, et al 1999; Bohn 2011) in light of the political economy of public sector debt decisions (Persson and Tabellini 2000; Alesina and Perotti, 1995). Third, an extensive literature has considered the question of optimal asset allocation (Black 1989; Bodie 1990; Lucas and Zeldes 2006, 2009; Pennacchi and Rastad 2011).[1]

Missing in the literature has been an analysis of the revenue demands of the pension promises to public employees when considering the plans on an ongoing basis. If states and local governments are to pay pensions under current policies, how much more revenue will need to be devoted to these systems, both to pay down legacy liabilities and fully fund service accruals? This paper provides calculations of the increases in contributions that would be required to achieve fully funded pension systems in 30 years, a standard amortization period. These contribution increases are calculated relative to a base of Gross State Product (GSP) growth applied to today's contributions. Results are presented under a variety of possible assumptions about growth, asset returns, the treatment of future work by current employees, and the sensitivity of state and local growth to policy changes. We loosely call the latter effects "Tiebout effects" after Tiebout (1956).[2]

Contributions from state and local governments to pay for public employee retirement benefits, including the employer share of payments into Social Security, currently amount to 5.7% of the total own-revenue generated by these entities (all state and local taxes, fees, and charges). In aggregate, and assuming each state grows at its 10 year average with no Tiebout effects, government contributions to state and local pension systems must rise to 14.1% of own-

[1] Other papers have surveyed various labor market, behavioral, and political economy aspects of public pensions (Friedberg 2011; Beshears, et al 2011; and Schieber 2011). Shoag (2011) considers macroeconomic impacts of pension contributions. Fitzpatrick (2011) measures the valuation placed by a group of Illinois public employees on their pension benefits based on their choices to buy into additional retirement benefits.

[2] To be precise, the effect we consider is limited to taxpayers "voting with their feet," not the equilibrium provision of local public goods. The voting-with-feet phenomenon reflects the incentive to leave states with high tax burdens and worse public services in order to migrate to states with lower tax burdens and better public services.

revenue to achieve fully funded systems in 30 years. Average contributions would have to rise to 40.4% of payroll to achieve these goals, corresponding to an increase of 24.1% of payroll. This analysis starts from estimates of December 2010 asset and liability levels for state and local pension funds, and holds employee contributions as a percent of payroll constant at current rates.

These results may be best understood in terms of per-household contribution increases that would have to start immediately and grow along with state economies. The average immediate increase is $1,385 per household per year. In twelve states, the necessary immediate increase is more than $1,500 per household per year, and in five states it is at least $2,000 per household per year. A key feature of this analysis is that it accounts for the cost of new DB accruals, for both current and future workers, not just the cost of unfunded legacy liabilities. Decomposing the results into these two components reveals that 49% of the increased contributions would be required to pay only the present value of new service accruals.

These results are computed under an asset return assumption in which the pension fund assets earn a real risk-free rate of return, approximated by the yield on long-duration TIPS (1.7% as of December 2010) plus inflation. That is, we calculate required contributions under the risk-adjusted (or in finance terminology risk-neutral) mean real return. Considering the unadjusted return distribution would ignore the fact that the worst scenarios occur when marginal utility is highest. Under the risk-adjusted expected baseline, we also consider the possibility that public sector wages covary with priced risk factors (i.e., the market). When public sector salaries are exposed to priced risks, expected wages grow more slowly under the risk neutral measure than under the objective measure. Implementing wage risk in this fashion has a relatively modest effect on the results, reducing the required increases to $1,285 per household from $1,385.

In sensitivity analysis, we compute the costs under the 10th and 90th percentile of risk-adjusted asset growth, based on standard assumptions about the return properties of state pension fund assets. If only the 10th percentile outcome is achieved, the increase in the required contribution rises to $2,468 per household (24% of tax revenue). If the 90th percentile outcome is achieved, the increase in the required contributions drops to $756 (7% of tax revenue). The effects of the wage correlations are greatest when asset returns are low.

Introducing Tiebout effects, we examine how the results change when raising revenues or cutting services reduces a state's long-run economic growth rates, as taxpayers respond by relocating to states that provide more attractive services at lower prices. This has essentially no effect on nationwide totals and means, but increases the dispersion in needed revenues among states. States whose governments require the largest increases relative to GSP, such as Ohio, Oregon, New Mexico, and Illinois, would need the immediate increase to be several hundred dollars larger per household under a sensitivity parameter of two (two percentage point reduction in long-run GSP growth per percentage point of GSP raised in revenues), whereas states whose governments require the smallest increases see their required increases decline. The effects grow as the sensitivity parameter increases.

Measuring the revenue demands of public pension systems under current policy requires calculating "service costs" for the workers in the plans. These quantify the present value of newly accrued benefits, which is the cost of the increase in pension benefits plan participants earn by working one more year. State and local systems follow GASB rules and discount the pension liabilities using expected returns on assets. Using Treasury inflation-linked yield curves to measure the present value of deflated benefit promises, we find that with the possible exception of Indiana, there is no state for which the current total contributions by all state and local government entities are greater than the present value of newly accrued benefits for those entities. At least thirteen states would need to double contributions just to pay this service cost.

The paper then examines how much the required contribution increases would be reduced under several policy changes that reduce future benefit accruals. To start, we perform the analysis assuming that all new hires receive defined contribution (DC) plans, as has happened in Utah and Alaska and been proposed in Florida.[3] We assume that the DC plan will cost the employer 10% of payroll. Assigning new hires to DC plans is known as a "soft freeze" of the DB plan. We also assume that new workers in plans whose workers are currently excluded from Social Security (representing around 30% of today's public employees) would have to be enrolled in Social Security. We model two scenarios for the allocation of the 12.4% of payroll cost of the new Social Security contributions: either it is borne entirely by the employer, or it is shared equally between employer and employee.[4]

Our analysis shows that soft freezes have moderate revenue-saving effects. The required increases decline from $1,385 to $1,210 per household, excluding Tiebout effects and wage risk,

[3] In the baseline analysis under no policy changes, we have incorporated the fact that soft freezes are already effective in Utah and Alaska.

[4] From a statutory perspective, employers and employees share the Social Security contributions equally. The question is whether employees would need to be given a pay increase of up to 6.2% in order to accept the arrangement.

and assuming the employer bears the full cost of new Social Security entrance. By making the employer responsible for DC contributions of 10% of payroll plus the entire 12.4% Social Security contribution, these calculations by assumption make the soft freeze relatively expensive for systems where employees are not in Social Security. As a result, soft freezes under the above parameters reduce the fiscal burden for all but seven of the states that have not already closed DB plans to new workers. The exceptions are states that have relatively high employee contribution rates with low Social Security coverage: Ohio, Illinois, Colorado, Massachusetts, Missouri, Louisiana and Maine. For those states, moving to a cost structure where the governments bear the costs of paying 10% of payroll into a DC plan plus the entire 12.4% Social Security contribution would be more costly than actually funding the DB promises for new workers. If Social Security costs are shared, then Ohio, Colorado, and Maine are the only states that still do not benefit from a soft freeze with no other plan changes.[5] These results also vary with return assumptions and the correlation of wages with returns. At the 90th percentile return, soft freezes would have very little cost savings.

An alternative policy that has not, to our knowledge, yet been implemented by any public DB system but that is not uncommon in the private sector, is a "hard freeze." Under a hard freeze all future benefit accruals are stopped, even for existing workers. No earned benefits, including cost of living adjustments (COLAs) are revoked, but benefits cease to grow with service and salary. We assume that retirement benefits for all future work under a hard freeze would be compensated with a DC plan with the same parameters and cost sharing as in our soft freeze scenario, including Social Security for those employees currently excluded from the system. Hard freezes have more significant revenue-saving effects. If all plans were hard-frozen, total increases would average only 4.8% of own-revenue, or $800 per household. This analysis assumes that public employees would accept DC plans with a 10% employer contribution (which is relatively generous by private sector standards) without compensating salary increases, with the employer picking up the full cost of any Social Security enrollment. If Social Security costs for new entrants could be shared equally between employer and employee, the total increases decline to 4.2% of total own revenue or $701 per household. Under a soft freeze, the effect of

[5] Such an analysis necessarily does not reflect one advantage of DC plans, namely that their transparency ensures there will be no unfunded liabilities or unrecognized public sector borrowing through pension promises.

different asset return assumptions is somewhat more muted than under the baseline, and under a hard freeze it is even more muted.

This paper proceeds as follows. In Section I we explain the institutional background behind public sector DB plans in the U.S. and detail this paper's contribution to the literature. In Section II we describe the data and the aggregation of the systems to the state and local level, and sketch out current revenue and pension contribution policy. In Section III, the model for making these calculations is presented in detail. In Section IV we present and discuss the results. Section V concludes.

I. Institutional Background and Literature

Most U.S. state and local governments offer their employees DB pension plans. This arrangement contrasts with the defined contribution (DC) plans that now prevail outside the public sector, such as 401(k) or 403(b) plans, in which employees save for their own retirement (often with matching employer contributions) and manage their own investments. In a DB plan the employer promises the employee an annual payment that begins when the employee retires, where the annual payment depends on the employee's age, tenure, and late-career salary. For a sample of the large public finance literature on the costs and benefits of DB and DC plans, see Bodie, Marcus, and Merton (1988), Samwick and Skinner (2004), and Poterba, et al (2007).

When a government promises a future payment to a worker, it creates a financial liability for its taxpayers. When the worker retires, the state must make the benefit payments. To prepare for this, states typically contribute to and manage their own pension funds, pools of money dedicated to providing retirement benefits to state employees. If these pools do not have sufficient funds when the worker retires, then the states will have to raise taxes or cut spending at that time, or default on their obligations to retired employees. When governments promise deferred compensation in the form of DB pensions to employees when they retire, but do not set aside sufficient funds to honor those promises, they are effectively borrowing from future taxpayers. As a result, the definition of "sufficient funds" is important.

Government accounting procedures in this area contrast with the financial dictum that cash flows should be discounted at discount rates that reflect their risk. Under guidelines established by the Government Accounting Standards Board (GASB) state and local governments discount their pension liabilities at *expected returns on their plan assets*. Plans' actuarially recognized liabilities are therefore mechanically decreasing in the riskiness of the investments. Plan actuaries typically assume that the expected return on their portfolios will be about 8 percent, and then measure the adequacy of assets to meet liabilities based on that expected return. This accounting standard sets up a false equivalence between relatively certain pension payments and the much less certain outcome of a risky investment portfolio (see Gold 2002; and Bader and Gold 2004).

As Brown and Wilcox (2009) point out, DB pension promises based on current levels of service and salary are likely to be paid in full.[6] Novy-Marx and Rauh (2008, 2009, 2011a, 2011b) discount pension liabilities at rates that reflect their relatively low levels of risk, arguing primarily for the use of the Treasury yield curve to discount nominal payments. They focus on the accrual measure called the Accumulated Benefit Obligation (ABO), which essentially equals the present value of what would be owed if the plan were frozen and workers did not earn the rights to any benefits beyond what they would be entitled to based on today's service and salary. Other possible measures of obligations take into account some of the increase in benefits expected with future service. The present values of these broader measures, however, cannot be compared to today's assets in pension funds since counting the present value of future benefit accruals would also require calculating the present value of future contributions.

A key difference between this paper and Novy-Marx and Rauh (2011a) is therefore that this paper requires an explicit calculation of the annual economic cost of the new retirement benefits earned by existing workers. In the baseline scenario without pension freezes or policy changes, the cost for these workers is the annual present value of new benefit promises, otherwise known as the service cost. In the baseline scenario with no policy changes, we calculate the contributions necessary to pay off any unfunded ABO liability that exists today over 30 years, plus the present value of all new benefit accruals over that time period.

A second important contribution of this paper over Novy-Marx and Rauh (2011a) is that we explicitly account for the costs of new hires. In the baseline scenario, the annual cost of a new worker is that worker's service cost. To model a soft freeze, or closing of the plan to new workers, the pension cost of new employees is assumed to be that of a DC plan with an employer

[6] A number of states enshrine the payment of pensions as an obligation within their constitutions, providing explicit guarantees that public pension liabilities will be met in full. Furthermore, state employees are a powerful constituency, making it hard to imagine that their already-promised benefits would be impaired. Indeed, Brown and Wilcox (2009) discuss that in major municipal debt crises of the past, bonds were restructured while pension debt was honored in full. Some examples of this are Orange County in the 1990s, and the bankrupt city of Vallejo, California currently. Another consideration is whether the federal government would bail out any state that threatened not to pay already promised pensions to state workers.

contribution equal to 10% of payroll, plus the cost of providing Social Security to new workers in those systems that do not currently enroll workers in Social Security. The cost of Social Security is 12.4% of payroll, which generally is split equally between employers and employees. Our primary analysis is based on the notion that workers not in Social Security would require pay increases of 6.2% to pay their share, so that the cost of both the employer and employee share would effectively be paid by the employer.

The soft freeze analysis is performed independently of any calculation of service costs. It is computationally convenient to calculate the contributions necessary to pay off the Present Value of Benefits (PVB) liability, which forecasts all future accruals for current workers, as opposed to the ABO. In other words, this calculation solves for the government contribution rates over the next 30 years that will be necessary, in conjunction with the plans' assets and investment return (inflation plus the current real yield), to pay all expected benefits, taking into account both employee contributions and the costs of paying DC benefits for new employees.[7]

We also consider the possibility of hard freezes, in which all benefit accruals are stopped, including for current workers. In a hard freeze no accumulated benefits are taken away, but employees stop accruing defined benefits with additional years of service and salary increases. Instead, each employee receives a DC account (in the case of corporations this is generally a 401(k) plan) and all contributions from the date of the freeze go into that account. Major corporations that have undertaken freezes include Verizon Communications, IBM, and Alcoa. In our modeling of a hard freeze, we assume that the governments need only pay off today's unfunded ABO liability over 30 years, with DC contributions for everyone going forward and the complete loss of future employee contributions to DB plans.[8]

An important issue is the treatment of inflation assumptions. In this paper, we model real cash flows, deflating nominal cash flows forecast along the lines of Novy-Marx and Rauh (2011a, 2011b) using the inflation assumption built into the forecast nominal benefit payments. Accordingly, our baseline assumption is that the real value of assets grows at the point on the TIPS yield curve that corresponds to the average duration of real liabilities (21 years), which is

[7] We also account for contributions that current workers make to the DB plans after the amortization period, but these have essentially no impact on the results as very few current employees will still be working for the plans in 30 years. See Section III for further details.

[8] Our analysis of pension freezes thus relates to a small academic literature on the effects of freezes on costs or firm value, including Comprix and Muller (2010), Milevsky and Song (2010), and Rauh and Stefanescu (2009).

1.7%. This assumption implies that the nominal value of assets grows at inflation plus 1.7%. In calculating service costs, we again use real Treasury yields (based on TIPS) to discount deflated cash flows, rather than nominal Treasury yields to discount nominal cash flows, to calculate the change in the present value ABO liability resulting from an additional year of work.

II. Data on Pension Systems at the State and Local Level

This section describes the data sources used in this study. Our ultimate analysis, given the potential fluidity of whether state or local governments are responsible for unfunded liabilities, aggregates all state and local pension systems within each state. Similarly, we aggregate revenue sources from the level of state governments and local governments to the state level. A key element of the descriptions in this section is therefore how the state and local government data are aggregated to the state level.

A. *Data on Defined Benefit Pension Systems*

Key ingredients in the calculations include all of the inputs that go into the cash flow calculations in Novy-Marx and Rauh (2011a, 2011b), as well as data on pension fund assets from those same sources. The primary dataset consists of information from Comprehensive Annual Financial Reports (CAFRs) of 116 pension systems at the state level used in Novy-Marx and Rauh (2011a), and information from the 77 local-system CAFRs used in Novy-Marx and Rauh (2011b), for a total of 193 pension plan systems. The sample plans consist of the universe of plans with more than $1 billion in assets. The critical inputs to the model from these reports are: the system's own reported liability, the discount rate used by the system, the accrual method employed by the system, the average and total salary of active workers, the ratio of workers who are separated and vested but not yet retired to those who are retired and drawing a benefit, the benefit factors in the benefit formulas, the actual benefit payouts in 2009, the cost of living adjustments, and the assumed inflation rates. These variables are all summarized in Novy-Marx and Rauh (2011a, 2011b).

We explain the methodology for estimating the cash flows on a plan-by-plan basis in Section III. The study provides estimates for the universe of state and local defined benefit plans by scaling up the cash flows from the state and local plans that we have to match the benefit payouts from the U.S. Census Bureau (2010a) at the level of each state. The Census Bureau provides measures of benefit payments at an aggregated level to all state and local government employees within each state. The scaling factor used is simply the ratio of total benefits of in-state public pension systems provided by the Census to benefits of in-state plans in our CAFR-based sample. The implicit assumption is that the trajectory of future cash flows of local plans that are not covered in our local-system sample are similar to those of the state and local plans for which CAFRs were obtained. The average adjustment across the 50 states is 6.7% and the median is 3.5%. The largest adjustment factors were for Nebraska (56.9%), Louisiana (35.6%), and Michigan (30.9%). The Census of Governments lists substantial numbers of small local plans in those states that are not captured in our sample of local reports.

To calculate pension assets at the state level, a similar procedure was followed. We aggregate all state and local plan assets as of June 2009 to the state level. We apply the adjustment factors above, which again are based on ratios of benefits for covered versus not-covered plans. Finally, we increase plan assets to reflect the higher levels of assets in 2010 than in 2009. We use an adjustment factor of 1.235, based on the 23.5% increases over this 18 month period documented in the Federal Reserve Flow of Funds.

To bring estimated liabilities to December 2010, we calculate from the CAFR database that stated liabilities grew at a 5.52% annual rate between plan years 2007 and 2008, and at a 5.51% annual rate between plan years 2008 and 2009.[9] Given the stability of this growth rate, we applied a 5.5% annualized growth rate to liabilities between June 2009 and December 2010, in order to predict the value of what stated liabilities under the systems' own accounting methods would be if they were disclosed as of December 2010.

Our calculations also require knowing which systems include their workers in Social Security. For this purpose, we begin with data from the Center for Retirement Research (2011) and augment it with searches of the systems' own websites. Of the state-level plans in our sample we find that 16% of plans do not participate in Social Security, representing 24% of total payroll. At the local level, there is less Social Security coverage. Around 36% of locally sponsored plans in the sample had no Social Security coverage, due in large part to the fact that many systems for public safety officials do not participate. Around 52% of the locally sponsored plans have all participants in Social Security. In the remaining 12% of the local plans, some groups (usually

[9] Casual observation of actuarial reports suggests that some of the liability growth was predicted by state and local actuarial models, but some is from the "actuarial loss" of realized outcomes on job separation and mortality being out of line with predicted values.

public safety officials) were excluded from Social Security whereas the rest of the employees were in Social Security.[10]

B. *Contributions to Pension Systems*

The study requires measures of contributions to state and local pension systems from both employees and governments. U.S. Census Bureau (2010a) contains data on total pension contributions to plans at each level of government, decomposed into government contributions and employee contributions, for 2008. Using calculations on contribution growth rates from Novy-Marx and Rauh (2011a), we estimate 2009 contributions based on the growth rate of employee and government contributions in the state plans covered by that study. When looking at contribution measures in systems that include Social Security, we add 6.2% of payroll to employer (and employee) contributions. The Appendix (Section A) provides further details.

C. *State and Local Revenues, Debt, and Payrolls*

The study also requires data on a number of revenue and spending figures at the state and local level. These variables are primarily used as scaling variables in our analysis, although historical growth in GSP is used in some of the scenarios to project future state-level income growth. Payroll of employees in the plans comes from the CAFRs themselves, with the scaling factors described above applied so as to capture workers in plans that our samples do not cover.

Revenue data from the U.S. Census Bureau 2010b are collected separately for the state and local level and then aggregated to the state level, so that the government revenues for a given state again reflect the aggregate of the state government and all local government entities within the state.[11]

We focus on two revenue measures. First, we consider a broad measure called Total Own Revenue that includes all revenue except (i) the "insurance trust" revenues reflecting the returns of pension funds themselves; and (ii) intergovernmental revenues, which are primarily transfers from the federal government but also transfers from state governments to local governments and

[10] Specifically, out of the 77 local plans, we located Social Security information for 67 of them. Of these, 35 had full participation, 8 had some employees exempted, and 24 did not participate in Social Security at all. Of the 8 that had some employees exempted, we assumed 80% of employees were covered, based on rough averages in the plans for which we could obtain precise information. For the 10 plans for which information was not available, we assumed coverage at the average level over all 77 local plans.

[11] Revenues at the state level are available for 2009. Local-level revenues are only available for 2008, so we assume that the 2009 ratio of local to state revenues remains the same as the 2008 ratio for each state.

vice-versa. The need to exclude transfers between state governments and local governments is obvious, as otherwise revenues would be double counted. We exclude federal transfers as the point of the exercise is to examine how much state and local revenues will have to grow to pay pensions in the absence of an expansion of federal assistance.

Second, we examine Tax Revenues alone. These exclude fees and charges, most of which are for services rendered. The idea here is to consider how state and local governments could pay for unfunded pensions through traditional taxation sources like income taxes, sales taxes, and property taxes. Compared to Total Own Revenue, scaling by Tax Revenues assumes that states will not raise fees for services such as university tuition to pay for unfunded pension liabilities.

The U.S. Census Bureau 2010b also contains data on debt outstanding at the state and local level, using a definition that excludes unfunded pension liabilities. As with revenues, debt information is collected separately for the state and local level and then aggregated to the state level, so that the government debt measures for a given state in our study again reflect the aggregate of the state government and all local government entities within the state.[12]

D. *GSP and Population*

Gross state product is from the Bureau of Economic Analysis (2010). We examine a 10-year history of gross state product growth by state for the baseline scenario in which the future growth rate for a state is assumed to be the 10-year historical average growth rate for the state. Population estimates are from the U.S. Census Bureau for the year 2009. To calculate the number of households we use the estimate from the latest decennial census of 2.59 individuals per household.[13]

E. *Summary Statistics*

Table 1 shows summary statistics. The level of observation is the state. The table begins with the levels of the key revenue and income variables. Total tax revenue was $1.2 trillion in 2009, and total own revenue was $1.9 trillion in 2009. Note that this includes revenues from both the state and local levels of government. Total GSP was $14.1 trillion, and there were 117.85 million households.

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[12] As with revenues, the state-government information is available for 2009 whereas the local-government information is only available for 2008. In estimating total state and local debt aggregated at the state level, we therefore assume that the 2009 ratio of local to state debt remains the same as the 2008 ratio for each state.

[13] See http://quickfacts.census.gov/qfd/states/00000.html.

The rest of Table 1 shows payroll, government contributions to DB pension plans, and employee contributions to DB pension plans, scaled by each base variable: tax revenue, total own revenue, GSP, and number of households. Total government payroll was $678 billion in 2009, amounting to 55.8% of tax revenue, 34.8% of total own revenue, 4.8% of GSP, and $5,757 per household. There is dispersion in these quantities. For example, Nebraska spends only 2.9% of GSP on state and local payroll, while New Mexico spends 6.2% on state and local payroll.

Government contributions are shown two ways: first including the employer's share of Social Security (6.2% of payroll) in systems that participate in Social Security, and then excluding the employer's share of Social Security. In states where no public workers covered by DB pension plans participate in Social Security, the contributions including Social Security and excluding Social Security are the same.

Total government contributions in 2009, including Social Security contributions, amounted to $110.9 billion, and excluding Social Security contributions were $80.7 billion. The Social Security contributions comprise 4.5% of aggregate payroll, suggesting a Social Security coverage ratio of around 73% of payroll. Aggregated across the 50 states, total government contributions average 16.3% of payroll, 9.1% of tax revenue, 5.7% of total own revenue, and 0.8% of GSP. The average per household government contribution to DB pension systems plus Social Security at the state level is $941. Excluding Social Security, the government contributions are lower on average by 2.5% (= 9.1% - 6.6%) of tax revenue and by 1.6% (= 5.7% - 4.1%) of total own revenue, and average to $684 per household.

Similar to the treatment of total government contributions, total employee contributions are shown two ways in Table 1: first including the employee's share of Social Security (6.2% of payroll) in systems that participate in Social Security, and then excluding that share. Across the 50 states, total employee contributions average 10.2% of payroll, 5.7% of tax revenue, 3.5% of total own revenue, and 0.5% of GSP.

Appendix Table A1 shows levels of contributions, payroll, and revenues for state and local systems, aggregated to the state level. The table is in descending order of per-household government contributions to DB plans, including Social Security. Colorado, whose workers do not participate in Social Security, contributed only 2.8% of total own revenue towards public employee pensions in 2009, the lowest value across the states, while Rhode Island contributed 9.3% (including to Social Security); the highest value. Colorado also contributed the lowest per household amount of $463, whereas New York contributed $1,739, the highest per-household amount. Excluding Social Security, North Carolina contributed the lowest per-household amount at $173 per household, while New York contributed $1,291 (as shown in Table 1).

Government contributions to DB systems are not mandated by any federal rules. GASB standards specify how state and local governments are to calculate service costs, or the present value of newly accrued benefits. These standards further guide state and local governments in calculating an Actuarially Required Contribution (ARC), which consists of paying the present value of newly accrued benefits plus a portion of the unfunded liability each year.

Not all governments contribute the ARC. Approximately 45% of state government systems in our sample paid less than the full ARC in 2009, 40% paid less than 90% of the ARC, and 25% paid less than 80%. Some systems paid very little, as reflected by the fact that the mean system that did not pay the full ARC paid only 73% of the ARC. Furthermore, the part of the ARC that represents the cost of new service (as well as the unfunded liability) is itself calculated using the expected return discounting methodology and therefore understates the true economic cost of new benefits. As a starting point for our analysis, we calculate the true present value of newly accrued annual benefits as a percentage of payroll, based on discount rates that reflect the risk properties of the benefit promises themselves.

III. Methodology

This section explains the methodology employed to determine benefit payments, calculate new service costs, and evaluate the contribution increases necessary to pay off states' unfunded pension obligations.

A. *Forecasting Benefit Payments*

A starting point for the analysis is the stream of cash flows that each system will pay out to beneficiaries. There are two fundamental challenges. First, the governments themselves do not disclose the series of cash flows that they have discounted. They disclose a present value of liabilities, a discount rate, and actuarial assumptions. As a result, the streams of cash flows must be reverse-engineered on the basis of the information provided.

Second, different calculations require cash flows related to liabilities that reflect service and salary as of different points in time. For example, in the baseline scenario with no policy changes we calculate the contributions necessary to pay off any unfunded ABO liability that exists today over 30 years, plus the present value of all new ABO benefit accruals over that time period. The ABO is often referred to as the "termination liability," because it recognizes only the portion of expected future pension benefits payments due to an employee's current wages and service. In the soft-freeze calculations, however, the most convenient formulation calculates the contributions necessary to pay off a broader liability concept, the PVB, which forecasts all future accruals for current workers including projections of estimated future service and salary growth.

The exercise of separately estimating ABO and PVB cash flows is further complicated by the fact that the actuarial liability employed by most systems is calculated from neither the ABO cash flows nor the PVB cash flows but rather (in the grand majority of cases) from a concept called Entry Age Normal (EAN). The EAN recognizes future liabilities in proportion to the ratio of the present value of a worker's wages earned to date and the present value of lifetime wages, which leads to service accruals that are a constant fraction of an employee's wages throughout the employee's career. In addition to presenting our baseline analysis under ABO benefit recognition, we also present alternative calculations using the EAN method of benefit recognition and demonstrate that the required tax increases are quite similar.[14]

Future payments to plan participants are estimated from the procedure detailed precisely in the Appendix, Section B. Here we describe the calculations in general terms. This is the same methodology as that employed in Novy-Marx and Rauh (2011a, 2011b) with two notable differences. First, the model is calibrated to match not only the expected first year payout to beneficiaries and the stated liability, but also the total wages of each plans' current active workers. Second, because we are interested in the plans' future *real* liabilities, we forecast real liability cash flows using the uniform inflation assumption of 2% per year, adjusting COLAs and wage growth assumptions appropriately to reflect the differences between this rate and the plans' stated inflation rate assumptions, for reasons discussed below.

There are three groups of plan members that must be considered: current employees, retirees, and separated vested workers (individuals that are no longer in public employment, are not currently receiving pension benefits, but are entitled to take them at some point in the future).

For each plan, we first forecast the nominal pension payouts to current employees recognized under the plan's own stated accounting method. We assume active workers' age and

[14] This similarity is not surprising since for a career worker the accrued cash flows under all the methods (ABO, EAN, and PVB) converge at retirement. Under EAN accounting, today's unfunded liability is larger than under ABO accounting, but benefit accruals going forward are smaller.

service distributions, as well as the average wages of employees at each level of age and service relative to the overall plan average wage, are consistent with their averages from a sample of CAFRs of the states with the largest total liabilities.[15] Total wages of active workers are taken directly from the plans' CAFRs. For each age and service level we assume workers are split evenly by gender, and forecast the expected number retiring at each year in the future, and their salaries at the time they retire, using assumptions on wage growth and separation probabilities by age derived from the same CAFRs used to calculate the age-service matrix.

Based on common practice and the observed age distribution of retirees, we assume that retirees are eligible for full benefits at age 60, but can start taking benefits as early as 55 by taking a linear 6% benefit reduction for each year they start taking benefits before age 60, consistent with common practice in state public pension systems.

This schedule, together with the fact that COLAs only apply after retirement, make early retirement more than actuarially fair to plan participants, so we assume that workers retiring younger than 55 will begin taking benefits at age 55, while workers retiring older than that will begin taking benefits immediately. For each retiring worker we calculate initial benefit payments using the worker's service and salary at the time of separation and the plan-specific retirement benefit factor. Expected nominal cash flows at each year in the future are then forecast using plan-specific COLAs and the RP-2000 mortality tables (combined employee/retired healthy), assuming that 60 percent of participants are married at the time they retire to a spouse of the same age and that plans allow for 50 percent survivor benefits.

For retired workers we assume a distribution of retiree ages, and for each age an average annuity benefit relative to the overall average plan annuity benefit, derived from CAFRs for which this information is available. Total benefits paid are taken directly from the CAFR of each plan. We then forecast nominal cash flows at each year in the future, again using plan-specific COLAs, and the RP-2000 mortality tables assuming that 60 percent of participants are married at the time they retire to a spouse of the same age and 50 percent survivor benefits.

The number of vested, separated members not yet receiving benefits is taken directly from CAFRs. Vesting typically requires five years of service, and workers rarely leave public employment with more than 15 years of service without retiring and taking benefits. We consequently assume that these members have between 6 and 15 years of service (each level

[15] See the Internet Appendix Table II.C. in Novy-Marx and Rauh 2011a for the precise age-service matrix.

equally likely), and that the age distribution at each service level is the same as that for currently employed workers with the same level of service. We assume a participant's benefits eligible salary is equal to the current average salary across plans of active workers with the same age and service. We then adjust this to reflect the experience of current retirees, by assuming that separated workers in plans in which current retirees receive large benefit payments relative to those in other plans will also receive similarly larger benefits when they retire. We assume separated workers will begin taking benefit payments at age 55, initially equal to 70% of their benefits eligible salary times their service times the plan-specific benefit factor. This 70% reflects the impact of taking payments five years before the age of full retirement under the linear 6% per year adjustment schedule. We then forecast cash flows at each year in the future using our standard methodology, employing plan-specific COLAs and the RP-2000 mortality tables with a 60% married rate and 50% survivor benefits.

In the final step of estimating the nominal cash flows, we calibrate our model to plans' stated liability by multiplying each series by a geometric sequence that starts at one, such that the total model generated cash flows recognized under the accounting methodology employed by the plan yields the plan's stated liability when discounted at the plan-chosen discount rate. This procedure uses the information contained in the plan level variation in stated liabilities to proxy for unobserved state level variation in other variables (e.g., the age-service distribution), without altering either the total salaries of the plan's current workers or the first year benefits payments to a plan's current annuitants. The average rate at which this geometric sequence grows is -0.35% for state plans and -1.48% for local plans, with standard deviations of 1.63% and 1.56%, respectively.

These cash flows are then calculated under each of four different accrual concepts: the three described previously (ABO, EAN, and PVB), as well as one other concept used in the reports of some plans called the Projected Benefit Obligation (PBO), which accounts for future expected wage increases but not future service.[16] Note that this adjustment only affects the cash flows related to the currently active workers.

The procedure up to this point yields a stream of nominal cash flows. For most of our calculations in this paper, however, we require cash flows in real terms. One way to obtain these

[16] In state and local government reports the PBO is generally referred to as a Projected Unit Credit (PUC) method. Under FASB accounting, firms calculate PBO liabilities and report unfunded PBO liabilities on their balance sheets.

is to deflate the cash flows using the states' own inflation assumptions. Doing so would, however, understate the true liability represented by participants not yet receiving benefit payments. This is because these participants' liabilities have a nominal component that is undervalued using the states' inflation rate assumptions, which are higher than consensus estimates or those implied by the bond markets. Benefit payments essentially represent a real liability once they begin because of the COLAs, but COLAs do not apply until a participant starts taking benefits. High assumed inflation rates consequently excessively deflate the liabilities of participants who are separated and vested but not yet receiving benefits, as well as those of any workers who will retire before the age at which they can start taking benefits.

When calculating the real liability cash flows we consequently use a uniform inflation assumption of 2% per year across plans, taken from the Federal Reserve Bank of Cleveland's estimates of inflation expectations.[17] When doing so we adjust COLAs downward by the difference in a plan's own inflation rate assumption and the uniform 2% assumption. We also reduce the wage growth by age assumptions to reflect the lower assumed rate of inflation, reducing assumed wage growth by the difference between the average inflation assumption across plans and 2%. This results in a new set of forecast nominal liability payment streams for each plan. These are then deflated using the 2% per year inflation assumption, yielding each plan's forecast real benefit payments.

As a final step, the resultant calibrated real liability streams are aggregated to the state level using the methodology explained in Section II. The scaling factor used for each state is simply the ratio of total benefits of in-state public pension systems provided by the Census to benefits of in-state plans in our CAFR-based sample. The implicit assumption is that the cash flows of local plans that are not covered in our local-system sample are similar to those of the state and local plans for which CAFRs were obtained. The average adjustment across the 50 states is 6.7% and the median is 3.5%.

We also calculate risk neutral expected benefit payments each year in the future, using the same methodology, under the assumption that public sector wages covary systematically with priced risk factors (i.e., the market), as in the models of Lucas and Zeldes (2006) and Benzoni, Dufresne, and Goldstein (2007). This has no impact on the ABO liability payments, as these

[17] The estimates, as well as the methodology employed to calculate them, can be found at http://www.clevelandfed.org/research/data/inflation_expectations/index.cfm?DCS.nav=Local.

contain no wage risk, but do affect the forecast recognized benefit payments under the EAN, PBO and PVB, which all account for expected wage growth. When public sector salaries are exposed to priced risks, then expected wages grow more slowly under the risk neutral measure than under the objective measure. The risk neutral growth in wages is reduced in proportion to both 1) the extent to which wages load on the market (their market beta), and 2) the magnitude of the equity risk premium.

We consider various assumptions regarding these two determinants of the risk premia associated with wage risk. The baseline analysis is conducted assuming zero effect, but we also present wage-risk scenarios based on the calibration in Novy-Marx and Rauh (2011a). Under a correlation of liabilities with the stock market of 0.25, a 6.5% equity risk premium, a market volatility of 0.16, and a volatility of liabilities of 0.05, one obtains a risk premium of 51 basis points. Evidence suggests that liabilities are not this correlated with the market over a 30 year horizon, although admittedly correlations could be very large on a long horizon. In untabulated results we also consider the effects if the wage-risk is 2 and 4 times larger and observe that the effects of additional wage risk on required contribution increases is close to linear.[18]

B. *Calculating New Service Costs*

The annual cost of a worker's new service accrual is the difference in the present value of expected future benefit payments calculated using the worker's current age, wages and service, and those calculated using the worker's age, wages and service from the previous year. We calculate the state-level service costs under both the ABO and EAN, which, as explained above, recognize future benefit payments differently. We also calculate the present values of the increases in the recognized expected liability payments both 1.) by using states' own assumed discount rates; and 2.) by deflating nominal cash flows at the inflation rate and discounting the resulting real cash flow stream using the December 2010 zero-coupon TIPS yield curve.

When calculating the service costs using states' own discount rate assumptions we forecast nominal liability payments using the states' own inflation assumptions and discount using the state-chosen nominal discount rates. However, for the reasons explained in Section III.A, when calculating the real liability cash flows we use a uniform inflation assumption of 2%

[18] Geanakoplos and Zeldes (2010) consider these issues in the context of Social Security. Note that there is less wage risk in a public employee DB pension formula than in the Social Security formula due to the fact that when a public employee separates from the job, all wage risk is gone. In Social Security, the earnings history is re-indexed to wages when the employee claims retirement benefits, which is not until age 62 at the earliest.

per year across plans, taken from the Federal Reserve Bank of Cleveland's estimates of inflation expectations. We discount these real cash flow streams using the December 2010 zero-coupon TIPS yield curve.

For the service cost calculation, we begin with the calculation of the stream of benefit payments (under the relevant actuarial method - i.e., ABO or EAN) to all current workers not retiring over the coming year. Because we exclude retiring workers, these forecasts do not include any payments in the following year. We then forecast the expected benefit payments to all workers one year later. We use two different methodologies for forecasting continuing workers' wages. We either assume that they grow in accordance with our model's assumptions regarding wage growth with age, or that they are consistent with the salaries of workers one year older and with one year more service from the preceding year, adjusted upward to reflect inflation. The two methodologies yield almost identical results, and the numbers we present in the tables that address this question (particularly Table 2) are averages of the two.[19]

Finally, plan service costs are aggregated to the state level, and adjusted to reflect plans not covered in our CAFR database, using the same procedure described in Section II, and reviewed at the end of Section III.A above.

As with the benefit payments, we also calculate service costs under the assumption that public sector wages covary systematically with priced risk factors. This is done using the methodology described above, using the risk-neutral expected growth in wages, where the wage growth is adjusted downward from the objective expected rate of wage growth to reflect various assumptions regarding the extent to which wages load on the market and the equity risk premium.

C. *Amortizing Legacy Liabilities While Keeping Current DB Plans*

This section explains how we calculate the rate, relative to wages or GSP, at which states and localities need to contribute for the next 30 years to completely amortize the unfunded pension liability, measured under either the ABO or EAN. After the 30-year amortization period the contribution rate is assumed to drop to the level required to fund new service accruals.

In the baseline scenario, each year plan assets are assumed to grow at a real rate of 1.71%, the 21 year zero-coupon TIPS yield, where this maturity is picked to match the duration

[19] See Appendix (Section C) for further details.

of the real pension liabilities at the corresponding yield. This is the real rate that may safely be achieved when assets are picked to match liabilities, and is equivalent to assuming that assets will grow at inflation plus 1.71%. Assets are then reduced by the benefit payments made that year, to reflect outflows to plan participants.

To these assets we add the contributions from plan participants, which are assumed to be a constant fraction of wages. For each state the contribution rate for plan participants is taken from the data, and averages just under 6%, though there is a great deal of variation across states. In Oregon, for example, plan participants make essentially no contributions to the DB plan, while in Massachusetts the employee contribution rate exceeds 10%. Plan participants' aggregate salaries are taken from the model, and account for mortality, retirement, and wage growth.

Finally, we add the contributions from employers, less the cost of new service accruals. State and local governments are assumed to contribute a constant fraction of total adjusted payrolls for the next thirty years, the "amortization rate." Total payrolls, as well as GSPs, are assumed to grow at a constant real rate, and we consider several different scenarios: growth consistent with individual states' experiences over the last ten years, growth consistent with the national experience over the last ten years, and each of these scenarios reduced by one percent.

Total assets *T+1* years in the future, A_{T+1}, are therefore given by

$$(1+r)A_T + \left(AR^* - (c^{NC} - c^{employee})\right)(1+g)^T W_0^{total} - B_T \ ,$$

where *r* is the asset real return assumption (1.71% real in the baseline), AR^* is the amortization rate (our primary object of interest), c^{NC} is the normal cost rate (service cost relative to wages, which in some scenarios is accounted for assuming priced wage risk), $c^{employee}$ is the employee contribution rate, *g* is the assumed growth rate in the state's economy and government sector, W_0^{total} is total wages today, and B_T is the deflated time-*T* benefit cash flows to retirees currently recognized under the accounting methodology (ABO or EAN). We search for the amortization rate AR^* such that assets thirty years in the future are just sufficient to pay the remaining recognized benefit payments owed to current workers, i.e., such that

$$A_{30} = \sum_{t=0}^{\infty} \frac{B_{30+t}}{\left(1+r_f\right)^{t+1}},$$

where r_f is picked to match the 21 year TIPS rate of 1.71%. If the assets together with expected investment earnings are insufficient to pay remaining future benefit obligations, then the algorithm tries a higher employer contribution over the next thirty years. If they are more than sufficient, then we try a lower rate. The algorithm searches until it finds the rate that just fully amortizes the legacy liabilities over the thirty year period.

We also consider the cost of amortizing the legacy liabilities under "high" and "low" asset growth rate scenarios. In these scenarios the assets are assumed to grow each of the next thirty years not at the real rate of 1.71%, but at the geometric average rate of return from the 90% and 10% levels of the risk-neutral distribution under an assumed 12% volatility on plan assets. The median outcome is lower than the mean outcome by the convexity adjustment, which with our assumed volatility on plan assets of 12% is given by $\sigma^2/2 = 0.12^2/2 = 0.72\%$ per year, while thirty year average annual returns at the 10% and 90% levels of the distribution are higher or lower than the median outcome by $N^{-1}(90\%)\sigma/\sqrt{30}$ = 1.28 x 12% / 5.477 = 2.81% per year. To implement the 10th and 90th scenarios, we also assume that the assets that are funding the new benefit promises will earn the scenario return out to the end of the 30-year amortization period. So the normal costs (c^{NC}) in the 10th percentile scenario are substantially higher than the normal costs in the baseline scenario and the normal costs in the 90th percentile scenario are substantially lower than in the baseline scenario.

We also account for the impact of wage risk in the high and low asset return scenarios. Under the 10th percentile scenario, for example, benefit promises grow more slowly when wages are correlated with the market, which partially offsets the increase in c^{NC} arising from the low asset return assumption. Conversely, under the 90th percentile scenario, wages and benefit promises grow more rapidly, which partially offsets the decrease in c^{NC} arising from the high asset return assumption.[20]

D. *Incorporating "Tiebout" Migration*

[20] Log-wage growth under the risk neutral measure is distributed $N\left(g - \beta_{g,mkt}\lambda_{mkt} - \frac{\beta_{g,mkt}^2\sigma_{mkt}^2}{2}, \beta_{g,mkt}^2\sigma_{mkt}^2\right)$, where g is the expected growth in wages under the objective measure, $\beta_{g,mkt}$ is the loading of wage growth on the market, λ_{mkt} is the equity risk premium, and σ_{mkt} is market volatility. With $\beta_{g,mkt}\lambda_{mkt}$ = 0.51%, a 6.5% equity premium and market volatility of 18% this implies thirty year risk-neutral growth rates in wages in the 10% and 90% scenarios 0.83% and 0.17% below the objective expected growth rate in wages, respectively.

If a state has to raise taxes and/or cut services more than other states to pay for legacy pension obligations, it makes residency in the state relatively unattractive. This affects the marginal decisions of both state residents considering out-migration and other states' residents considering in-migration. While this should be at least partially reflected in lower property values, it also reduces the state's rate of economic growth, as taxpayers choose to locate in states that provide better government services at lower prices.

The effect of taxes on economic growth is a question with some history in the macroeconomics and public finance literatures. Romer and Romer (2010) for example find that a tax increase of 1% of GDP reduces aggregate GDP growth by one percent per year over the following three years. Helms (1985) finds in a panel of states that an additional 1% of personal income raised through property taxes in the state reduces the level of personal income by 1.21% in the first year and in the long run by almost 15%, suggestive of a persistent impact on long-term income growth within the state. The fact that estimates at the state level are larger than estimates at the national level is consistent with the hypothesis that part of the state-level effect is due to individuals voting with their feet and leaving high-tax areas. In a municipal setting, Haughwout, et al (2004) find evidence suggesting that a number of cities are at the peak of their Laffer curves so that no additional tax revenue can even be raised. In these settings, raising a tax rate reduces the taxable income base proportionately, as residents move to lower taxed areas or into less heavily taxed activities.[21]

The analysis in this paper occurs at the level of the state. Our hypothesis is that the sensitivity of state GDP growth to taxation must be larger than that of the US as a whole. Compared to cities, however, states presumably have more capacity to increase tax revenues, as the ability of residents to relocate from one state to another is lower than their ability to move out of a city.

We model this change in economic growth rates in response to changes in taxes and services using a linear specification. Specifically, we assume that an increase in the revenues raised by state and local governments, and/or a reduction in the services they provide, measured as a fraction of GSP, relative to the national average, reduces the real growth rate of state GSP. That is, we assume that state *i*'s adjusted GSP and public sector growth rate is given by

[21] Other papers in public finance focusing on the elasticity of taxable income to tax rates at the macroeconomic level include Feldstein (1995) and Gruber and Saez (2004).

$$g_i^* = g_i - \beta\left(\frac{\left(AR_i^* - c_i^{old}\right)W_i^{total}}{GSP_i} - \frac{\sum_{states}\left(AR_j^* - c_j^{old}\right)W_j^{total}}{\sum_{states} GSP_j}\right),$$

where g is the growth rate absent Tiebout effects, β is the sensitivity of GSP growth to tax increases and/or service cuts, $AR*$ is the amortization rate accounting for Tiebout effects, c^{old} is the old contribution rate to pension plans, and W^{total} is total public sector wages.

The literature cited above (Romer and Romer 2010; Helms 1985) is broadly consistent with β = 1, i.e., an increase in taxes by one percent of GSP reduces GSP growth by one percentage point. In our analysis we consider a range of parameters. Specifically, we assume that an increase in taxes and fees (or reduction in services) of one percent of GSP greater than the average states' reduces the GSP growth rate by either one percentage point (β = 1), two percentage points (β = 2) or three percentage points (β = 3).

E. *Accounting for Municipal Debt*

States may use off-balance-sheet debt, in the form of pension underfunding, as a complement (not substitute) to municipal debt. Alternatively, the revenue demands of dramatically underfunded pension plans may force these plans' states to finance their operations at least partly through municipal borrowing. In either case, ignoring municipal debt understates the dispersion in the states' financial well-being. There are limits to the extent to which states that are currently issuing a high volume of bonds can continue to do so, while states with very little general obligation or pension obligation bond debt could begin to pay some obligations through municipal debt issuance.

A more sophisticated analysis of the amortization of states' legacy pension liabilities accounts for variation in municipal indebtedness. We do this by adjusting current pension fund assets to reflect differences in non-pension debt. Specifically, we replace state *i's* pension fund asset with its "adjusted assets," given by

$$A_i^* = A_i - D_i + \left(\frac{\sum_{states} D_j}{\sum_{states} GSP_j}\right) GSP_i.$$

If a state's aggregate municipal debt relative to GSP exceeds aggregate national municipal debt relative to national GDP, we reduce its pension fund assets to reflect the difference. Conversely, if a state's debt is relatively small relative to its economy, we add the difference to its pension fund assets.

F. *Amortizing Legacy Liabilities Under a Soft Freeze*

Under the soft freeze scenarios, we calculate the amortization rate, relative to wages or GSP, at which states and localities need to contribute for the next 30 years to completely amortize the legacy liabilities associated with old DB plans, under the assumption that all new hires participate in Social Security and a DC plan.

New employees are assumed to receive pension benefit contributions from their employers totaling 16.2%. They receive 6.2% in the form of employer contributions to Social Security, and 10% in the form of higher wages, employer contributions to a defined contribution plan, or some mix of the two. That is, we effectively assume that new employees are compensated for the loss of DB pension accruals with an increase in other total compensation of 10%, plus inclusion in Social Security if not previously enrolled. In our "Employer" scenarios salaries are adjusted up 6.2% for new hires in entities that were not previously part of Social Security, to offset the effective pay cut these workers receive when they are asked to contribute to the system, while in our "Employer-Employee" scenarios employees bear this cost themselves. The employer contribution to the old DB plans is the portion of the total employer payroll that does not go to new workers.

Future benefit payments are funded using plan assets and investment earnings, new contributions from plan participants, and new contributions from the states and localities. State and local contributions to old plans are equal to their total contribution to all plans, less their contribution to new plans. Total assets *T+1* years in the future, A_{T+1}, are consequently given by

$$(1+r)A_T + c^{employee(DB)} \cdot W_T^{old} + AR^*(1+g)^T W_0^{total} - c^{employer(DC)}\left((1+g)^T W_0^{total} - W_T^{old}\right) - B_T^{PVB},$$

where $c^{employee(DB)}$ is the employee contribution rate of old workers to their *DB* plans, W^{old} is these workers' wages, $c^{employer(DC)}$ is the effective employer contribution rate for new hires on DC plans, and B_T^{PVB} is the total risk-neutral expected benefit cash flows paid to retirees, which in some scenarios is accounted for assuming priced wage risk. The first term represents principle and investment earnings on the previous year's assets, the second term is the contributions of working plan participants, the third term is the total contribution of employers to pension plans, both old and new, the fourth term is the employer contributions that go to new workers' DC plans, and the last term is the payout to DB plan beneficiaries.

At the end of 30 years we require that plan assets, in conjunction with the negligible future contributions on the salaries of the remaining active workers covered by the old DB plan (employee, plus employer at the DB contribution rate), are just sufficient to pay the plan's remaining liabilities. That is, we require that

$$A_{30} = \sum_{t=0}^{\infty} \frac{B_{30+t}^{PVB} - \left(c^{employee(DB)} + c^{employer(DC)}\right) W_{30+t}^{old}}{\left(1 + r_f\right)^{t+1}}.$$

We also again consider "high" and "low" asset growth rate "scenarios" when calculating the cost of amortizing the legacy liabilities under a soft freeze. In these scenarios the assets are again assumed to grow each of the next 30 years not at the real rate of 1.71%, but at the geometric average rate of return from the 90% and 10% levels of the risk-neutral distribution.

IV.G. Amortizing Legacy Liabilities Under a Hard Freeze

We calculate the amortization rate under the hard freeze scenarios in the exact same way, except that we 1) use the ABO instead of the PVB to determine cash outflows to retired plan participants; 2) assume that participants in the old DB plans stop contributing to these plans, as they are no longer accruing new benefits; and 3) assume that participants in the old DB plans also receive new DC plans, and Social Security if they previously lacked it, and that employers contribute to these plans at the same rate that they do for new hires.

That is, total assets *T+1* years in the future, A_{T+1}, are given by

$$(1 + r)A_T + \left(AR^* - c^{employer(DC)}\right)(1 + g)^T W_0^{total} - B_T^{ABO}.$$

We again search for the amortization rate *AR** such that assets 30 years in the future are just sufficient to pay the remaining benefit payments owed to participants of the old, frozen DB plans, i.e., such that

$$A_{30} = \sum_{t=0}^{\infty} \frac{B_{30+t}^{ABO}}{\left(1 + r_f\right)^{t+1}}.$$

As in the soft freeze scenarios we also consider high and low asset growth rate scenarios, where the risk free real rate in the asset evolution equation is replaced by the geometric average rate of return from the 90% and 10% levels of the risk-neutral distribution.

IV. Results

In this section, we discuss the results. Section A presents our calculations of the service costs, the true present value of newly accrued benefits. Section B presents calculations of the necessary contributions for pension systems to be fully funded in 30 years' time, assuming no policy changes. Section C discusses how that calculation would vary if the tax base shifts from states that have to raise taxes more to states that have to raise taxes less. Section D presents the results that consider the impact that limits to debt issuance might have on the calculations. Section E discusses the effects of soft and hard freezes on the calculations.

A. *Service Costs*

If governments are conforming to GASB standards and paying the ARC, then they are paying this present value under their returns-based discount rates, as well as making some payments towards amortizing unfunded liabilities. Of course, as explained in Section II, not all states pay the ARC. Furthermore, even states that do pay the ARC are valuing new benefit promises using the expected return assumptions used to discount pension promises more generally.

We begin with calculations of the service costs as a percent of payroll for state and local systems aggregated to the state level, under both stated discount rates and Treasury discount rates, and using both the ABO and the EAN methods. Most state and local governments themselves use the EAN method, which as explained in Section III recognizes liabilities earlier in worker careers in such a way as to make the service cost a constant fraction of wages over the worker's lifetime, but it is the ABO method that reflects the actual market value of benefits earned in a given year. Compared to the EAN method, the ABO method involves higher service costs but lower recognized liabilities today.

Figure 1 provides a graphical representation of how the service costs are calculated. The top two lines in Figure 1 show the year by year forecast of the expected benefit payments recognized under the EAN (solid line), and those recognized the previous year under the EAN for the same workers (dashed line).[22] The bottom two lines show the expected benefit payments recognized under the ABO (dotted line) and those recognized the previous year under the ABO for the same workers (lowest line). The present value of the difference in the top two lines yields

[22] A similar analysis of the year by year benefit payment recognized under the PVB, which accounts for all future wage growth and service accruals, and those recognized the previous year for the same workers, yields essentially no difference, providing additional validation of the model.

the EAN service cost, and the present value of the difference in the bottom two lines yields the ABO service cost. Note that these service cost calculations exclude Social Security. In the analysis presented in our main results tables, Social Security is treated as costing 6.2% of payroll for both employer and employee, and we assume that employers who newly enroll employees on Social Security must provide a 6.2% pay increase.

Table 2 provides the service costs for each state under each of the two liability recognition methods (EAN and ABO) and each of the two discount rate methods (state-chosen and Treasury yield curves). Again, each row represents the total of all state and local government systems within a given state. In total, ABO service costs under state-chosen discount rates are 17.8% of payroll, whereas under Treasury rates they are 29.5% of payroll, a difference of 11.7% of payroll. EAN service costs under state-chosen discount rates are 13.9% of payroll, but under Treasury rates they are 28.2% of payroll, a difference of 14.3% of payroll.[23] The true present value of new benefit accruals thus averages 12-14 percent of payroll more than the costs recognized under GASB.

The 28.2-29.5% of payroll cost of the DB pensions compares to total (employer plus employee) contributions to DB plans of 17.7%. Those contributions are roughly equal to ABO service costs under state-chosen discount rates, but are 10-12 percentage points of payroll less than service costs calculated using Treasury rates.

The table is sorted in descending order of the ratio of service costs under the ABO method using Treasury discounting to actual contributions made. The ratio of service costs under the EAN method using Treasury discounting is also provided. The table shows that in all cases except one (Indiana under the EAN method), contributions in 2009 fell short of the present value of new benefit promises when measured under the Treasury rate. In Oregon, the true present value of benefits is 3.2-3.6 times the amount contributed, and in thirteen states it is over 2 times on both the ABO and EAN recognition methods, and in two additional states it is over 2 times the ABO but not the EAN service cost.[24]

Appendix Figure A1 shows the close relationship between our calculations of service costs and the plans' benefit factors. Initial benefit payments are proportional to final wages,

[23] The difference between the ABO and EAN service costs essentially represents the difference between the growth, due to one year's less discounting, of the EAN and ABO liabilities.

[24] If a state or local government contributes the full present value of new services accruals, but undertakes no actions to reduce the unfunded liability, then the unfunded liability continues to grow at the risk-free rate, adjusted for any exceptional returns realized by the fund's assets.

service at the time of retirement, and the benefit factor employed in the benefits calculation. The primary determinant of annual service costs is therefore not surprisingly the product of total wages and the benefit factor.

B. *Economically Required Contributions without Policy Changes*

Paying the full present value of the service cost would not address the unfunded liability. In fact, the unfunded liability would still continue to grow, just as any debt that is not being serviced continues to grow. The left two vertical panels of Table 3 summarize the contributions necessary to pay the present value of new benefits and amortize today's unfunded liabilities over 30 years. In other words, the goal is to end up with fully funded systems in 30 years. In Table 3, the present value of new promises and the amortization of unfunded legacy liabilities are calculated under the Accumulated Benefit Obligation (ABO) accrual method. In Appendix Table A2, we present similar analysis using the EAN accrual method, which results in greater unfunded liabilities that must be amortized, but lower service costs that must be paid as they are accrued.

The first column of Table 3 shows that if each state is given its 10-year average real GSP growth rate going forward, contributions must rise in aggregate to 40.4% of payroll per year across public employee pension plans in the United States. The mean is 38.3%, and the standard deviation is 6.6%. North Carolina requires the smallest contribution as a percentage of payroll, 24.7%. Colorado requires the largest, 53.9%.[25] As a share of tax revenue, the weighted average contribution requirement is 22.6%, and as a share of total own-revenue it is 14.1%. As a share of GDP the overall required contribution is 2.0%. The contribution to pensions per resident household must rise to $2,326, with Indiana requiring only $1,211 and New York requiring the largest annual per-household contribution: $3,989.

The column under "Total Required Contribution: 10yr Average GSP - 1%" models a 1% smaller GSP growth in each state. This raises required contributions as a share of own-revenue from 14.1% to 14.8%, as slower growth implies larger contributions today as a share of revenues, payroll, and GSP.

Appendix Table A2 provides several robustness checks. In the first vertical panel of Appendix Table A2, we eliminate the state-by-state variation in GSP growth rates and assume

[25] This is after the application of the COLA decreases implemented by Colorado in 2010. Similarly, the 2010 COLA decreases for Minnesota were also implemented, as well as the COLA suspensions in New Jersey and Rhode Island.

that all state economies grow at the GSP-weighted average real U.S. GSP growth rate from the past 10 years, 1.98%. Harmonizing the growth rates across states has little effect on the averages. However, eliminating the state-by-state variation in growth rates does reduce the variability of state outcomes. For example, under its own historical GSP growth rate, state and local funds in Illinois must contribute 20.2% of own revenues to pensions, the highest of any state.[26] Under the national average GSP growth rate, the highest contribution required by any state as a share of total own revenue is New Mexico at 19.2%. The standard deviation falls from 3.3% to 3.1%.

In the second vertical panel of Appendix Table A1, we repeat the first column of Table 3 but under the EAN method instead of the ABO method. This adjustment raises the required contributions. In this specification, the plans must be fully funded on an EAN basis at the end of 30 years, and the EAN recognizes a greater portion of total expected future benefit payments.

The left two vertical panels of Table 3 show the total necessary contributions, but of course state and local governments are already making contributions, so an important question is how much the contributions must rise. The right two vertical panels present the required contribution increases. Here we see that the weighted-average contribution increase across all pension systems is 24.1% of payroll. That means that state and local governments need to come up with an additional 24.1% of worker salaries if they want to start paying the full present value of new benefit promises and amortize unfunded liabilities over 30 years to achieve full funding at that point. These increases amount to 13.4% of tax revenue, 8.4% of total own revenue, and 1.2% of GSP per year. On a per-household basis, the required increase is $1,385 per U.S. household per year. If GSP growth is one percentage point slower, the required per-household contribution increase is 8.6% larger.

Table 4 shows the required contribution increases by state, in descending order of the required increase per resident household. In twelve states, the necessary increases are more than $1,500 per household per year, and in five states they are at least $2,000 per household per year. At one extreme, New York would need to raise an additional $2,250 per household, and at the other extreme, Indiana requires increases of only $329 per household. As a share of GSP, Ohio and Oregon require the largest increases, at 1.9% of GSP, followed by New Mexico at 1.8% of GSP.

[26] This accounts for the higher retirement ages and other changes implemented for new workers in the Illinois pension reform of 2010.

Table 4 also displays the portion of these required increases that would be necessary to pay only the true present value of new accruals each year. Recall that the total required contribution equals the required contribution to pay new service accruals plus the required contribution to pay down the unfunded liability over 30 years.[27]

The final row of the table shows that of the $163.2 billion in total required annual contribution increases, 49% or $79.6 billion is necessary to pay only these service costs. Another way of interpreting this finding is that the $2.5 trillion in unfunded state pension liabilities measured in Novy-Marx and Rauh (2011a) plus the $0.6 trillion in unfunded local pension liabilities measured in Novy-Marx and Rauh (2011b) only represent around half the necessary required resources to achieve full funding in 30 years, in the absence of further changes to benefit accruals.

States whose systems have regularly contributed less than even GASB guidelines have particularly large required contribution increases to amortize unfunded liabilities. States whose systems have recently made reforms to the new accruals for some portion of the workforce (usually just for new employees) have particularly small service cost components. Illinois is an interesting example. On the one hand, it has very large unfunded legacy liabilities, and current employees are still accruing benefits under the old rules. On the other hand, employees hired since January 2011 face stricter parameters, including a full retirement age of 67, a pensionable salary maximum of $106,800 per year, and a COLA that is the lesser of 3% or half of the CPI. Thus, most of the Illinois requirement is due to unfunded legacy liabilities, though an increase of $382 per household is still required just to pay service costs.

Table 5 shows the sensitivity of these calculations to different assumptions about wage covariance and asset returns. The first two columns show our baseline results, and are simply a repetition of the baseline results on contribution increases from Table 3. The second two columns account for the fact that if government wages covary with priced risk factors, then new accruals should be discounted at higher rates that reflect these risks. That is, if the wage risk is exposed to priced risk factors, than wages grow more slowly under the risk neutral measure than under the objective measure, reducing the value of future benefit accruals. The third and fourth columns present results generated by incorporating this wage risk, where these risks carry a

[27] We implement this calculation by considering the (counterfactual) assumption that assets in place are fully sufficient to pay all accrued legacy liabilities. The remaining contributions are therefore for service accruals.

premium of 51 basis points per year, consistent with aggregate public sector wage volatility of 6%, a 25% correlation with the market, and an equity risk premium of 6.5% as explained in Section III.

The remaining columns of the table report results under two different asset return scenarios: realized 30 year average asset returns at the 10% and 90% levels of the risk neutral distribution of possible outcomes. The median outcome is lower than the mean outcome by the convexity adjustment, which with our assumed volatility on plan assets of 12% is given by $\sigma^2/2 = 0.12^2/2 = 0.72\%$ per year, while thirty year average annual returns at the 10% and 90% levels of the distribution are higher or lower than the median outcome by $N^{-1}(90\%)\sigma/\sqrt{30}$ = 1.28 x 12% / 5.477 = 2.81% per year. In the 90th percentile asset return scenario, contribution increases are significantly lower, because both the assets that plans currently hold and the new contributions made to amortize legacy liabilities and fund new benefit accruals generate additional investment earnings that can be used to reduce the required contribution increases. Even this rosy scenario requires, however, that states increase contributions, and thus raise taxes, cut services, or increase employee contributions by 13.4% of pay or 7.3% of tax revenue. In the 10th percentile asset return scenario, contributions would have to rise by 42.9% of payroll or 23.9% of tax revenue.

Table 5 also shows the effects of wage risk on the required contribution increases under the 10th and 90th percentiles. With wage risk workers' salaries, and consequently their benefits, grow faster in the same states of the world in which plan assets perform well. The results show that the effects of adding wage risk are larger at the 10th percentile than at the mean, and larger at the mean than at the 90th percentile. Specifically, at the 10th percentile, wage risk reduces the required contribution by 3.6% of payroll (= 42.9% – 39.3%), whereas at the 90th it reduces the required contribution by only 0.4% of payroll (= 13.1% – 12.7%). There exists a point higher in the risk-neutral distribution of wage growth above which adding wage risk would increase the required contribution, relative to the required contribution at that point in the distribution without wage risk.[28]

C. *Effects of a Mobile Tax Base*

[28] Specifically, this would be the case above the point in the risk-neutral distribution where wage growth equals the *objective* expected wage growth, which happens at around two standard deviations above the risk-neutral mean.

In this section we incorporate the possibility that taxpayers will respond to attempts by states to increase taxes and/or cut services. Specifically, an increase in the revenues raised by state and local governments, and/or a reduction in the services they provide, measured as a fraction of GSP, relative to the national average, is assumed to reduce the real growth rate of state GSP. Effectively, growth is redistributed from states that have to raise taxes and cut services a lot to those that have to raise taxes and cut services less.

The top panel of Figure 2 displays the results for the states facing the largest increases under four different coefficients for these mobility effects: 0 (the baseline), 1, 2, and 3. The dispersion among states is increasing with the mobility parameter. At sufficiently high parameterizations there would be no level of taxation sufficient for Ohio or Oregon to amortize their legacy liabilities. The tax burdens and service cuts become so onerous that residents flee at a rate that makes paying the benefits impossible. The bottom panel of Figure 2 displays the results for states facing the smallest required increases. For public systems in Utah and Indiana, the Tiebout effects all but eliminate the required contribution increases.

Appendix Table A3 shows that even incorporating a Tiebout parameter of 2 has only a very small impact on the average contribution increases, although this does increase the standard deviation and the extremes. For example, the standard deviation of the contribution increase as a percentage of own-revenue is 2.6% without this Tiebout effect (see the third set of columns Table 3) and 3.3% with the Tiebout effect. The small differences in averages, e.g. 24.9% of payroll with Tiebout and 24.1% without, are due to the fact that the better states have higher growth rates and therefore rely more on bigger payments at the end of the amortization period.

Appendix Table A4 lists the required contribution increases by state in decreasing order of per household dollar amounts, inclusive of these tax base mobility effects. For example, Ohio now has to raise contributions by $2,552 per household, as opposed to $2,051 in Table 4. The extent to which systems are affected is related to the required increase as a share of GSP in Table 5. Ohio and Oregon therefore see more substantial tax base mobility effects. Oregon's requirements rise from $2,140 per household excluding the Tiebout effects (Table 4) to $2,415 per household including the effects. Outside of the top 10 states, there is relatively little effect. Inclusive of the mobility effects, the states in the best shape have to increase contributions even less, because their tax bases grow as people fleeing states with significant tax increases move in.

D. *Debt Issuance Limitations*

Some states have issued substantial amounts of general obligation or pension bonds in order to close deficits and meet pension contributions. As shown in Table 6, state and local governments in states such as Kentucky, Massachusetts, and New York have debt of more than 25% of GSP when aggregated to the state level. The state of Illinois routinely makes its current pension contributions by issuing (taxable) bonds. If there is no limit on debt issuance then states could effectively pay for pensions by borrowing for a long time, at least until the costs of servicing the debt began to affect the budget in a serious way.

Municipal debt is positively correlated with pension underfunding. Appendix Figure A2 shows this correlation graphically. Each additional dollar in municipal debt is associated with an additional 67 cents in ABO pension underfunding, and this relation is highly significant, with a test-statistic of 3.61. Off-balance-sheet debt in the form of pension underfunding does appear to be a complement to municipal debt.

Table 6 shows the effects of the limits on debt issuance for the states with the most positive and most negative debt effects. We model these effects not as a restriction *per se*, but as a reduction in pension fund assets to reflect the difference between a state's aggregate municipal debt relative to GSP and the ratio of aggregate national municipal debt to national GDP. This is the level of pension fund assets that plans would have if highly indebted states used pension fund assets to reduce their indebtedness down to the national average, while states with low levels of debt borrowed from muni markets and used the capital raised to fund their pension plans.

The debt effects we model increase the share of GSP that must be devoted to pension contributions in the most indebted states by a factor of 0.2-0.3 percent of GSP. In contrast, states with very little state and local on-balance-sheet debt could conceivably issue some debt to meet pension funding obligations, and for the states with the least current debt as a share of GSP, this reduces the share of GSP that must be devoted to pensions by 0.2 percentage points.

E. *Effects of Soft and Hard Freezes*

In this section we consider the impacts of soft and hard freezes. The top panel of Table 7 shows the necessary contribution increases (without Tiebout effects) for a soft freeze, and the bottom panel shows the analogous calculations for a hard freeze.

The top panel of Table 7 shows that soft freezes have moderate revenue-saving effects. Under the mean, the required aggregate increases decline from $1,385 to $1,210 per household if the cost of new Social Security enrolments is borne entirely by governments, and to $1,134 if the cost is shared between employers and employees.[29] Soft freezes under the above parameters reduce required contribution increases for all but seven states even if governments must pay the full costs of new Social Security enrolments. The exceptions are states that have relatively high employee contribution rates with low Social Security coverage: Ohio, Illinois, Colorado, Massachusetts, Missouri, Louisiana and Maine. In Ohio, for example, shifting new workers to a DC plan actually increases total revenue demands by $489 per household, from an increase of $2,051 to an increase of $2,540 per household. This can be understood by noting that currently, employees in Ohio systems contribute about 10% of pay and employers contribute about 11% of pay, with very little Social Security participation. If new workers are shifted to a DC plan under the modeled assumptions, employers will have to devote almost all of the 11% of pay they would otherwise have contributed to DB plans to the DC plan, plus they will have to pay 12.4% for Social Security inclusion, which is more than the amount by which their current contributions fall short of normal costs. The new employees' contributions now go towards their DC plan and cannot be used in the DB system. If the Social Security costs are shared, then only Ohio, Colorado, and Maine would still not benefit from the soft freeze.

Proposals for hard freezes of defined benefit (DB) pensions in the public sector have not reached the mainstream, but it is useful to examine the extent of cost savings that could potentially be achieved. The bottom panel of Table 7 shows the necessary contribution increase calculations under a hard freeze. We assume that in addition to the new workers, all future work by existing employees is compensated on the DC plan. Specifically, we assume DC plans cost employers 10% of wages, in the form of plan contributions, higher salaries, or some combination of the two. Analogous to the analysis of hard freezes, we present two scenarios for Social Security costs: 100% employer, and a 50-50 split between employer and employee. Under a hard freeze, the DB cash flows decline from the PVB cash flows to the ABO cash flows.

The bottom panel of Table 7 shows that for the baseline GSP growth scenario, contributions now need to rise by only 4.8% of total own revenue, instead of 8.4% in Table 5. Contribution increases per resident household under a hard freeze are still $800, due to the amortization of unfunded liabilities. For all states, a hard freeze generates a decline in required contribution increases, although substantial revenue increases or tax cuts are still required. If

[29] For Alaska and Utah, the figures going into the top panel of Table 7 are identical to those from the baseline analysis, as these states have already implemented soft freezes.

employees get DC plans instead of DB accruals, they will likely be compensated with employer contributions to these DC plans. In our analysis, we have calculated this cost in a similar way to the cost calculations performed for new hires under soft freezes. If public employees require even higher levels of compensation for the switch to DC plans then these cost savings would be even more muted.

Table 7 also presents the 10th and 90th percentile asset return scenarios for soft and hard freezes. It is interesting to note that if the 90th percentile return is achieved, a contribution increase of 13.1% of payroll is required both with the soft freeze (third column of Table 7) and without it (see the second to last column of Table 5). Without any policy changes, the newly accrued retirement costs would equal new DB accruals for all employees. Under the soft freeze, the newly accrued retirement costs are the same for existing employees but they are the DC contribution rates (plus Social Security where applicable) for the new employees. The fact that these are roughly the same implies that if 90th percentile returns can be guaranteed then new benefit promises under today's plan benefit parameters would not be any more costly than a soft freeze. The hard freeze scenario reduces required contribution increases to 9.4% of payroll at the 90th percentile.

At the 10th percentile, the cost savings of a soft freeze are most substantial, amounting to almost 10% of total payroll. Under the soft freeze new workers get fixed DC contributions, which are independent of the asset's performance. The normal costs of the DB plan that these new workers forego are highly dependent on the assumed discount rate. When new benefit accruals are discounted at the high returns assumed in the 90% scenario new DB accruals are no more expensive than the DC contributions, and the soft freeze generates essentially no savings. Conversely, when new benefit accruals are discounted at the low returns assumed in the 10% scenario new DB accruals are much more expensive, and the soft freeze generates substantial savings for the plan sponsor.

In Table 8 we present analysis that is analogous to Table 7 but incorporating wage risk with a wage-liability correlation parameter of $\rho = 25$. The addition of wage risk reduces the required contributions by 2.8% of payroll at the 10th percentile (from 33.0% to 30.2%), by 1.2% of payroll at the mean (from 21.0% to 19.8%), and only 0.4% of payroll at the 90th percentile (from 13.1% to 12.7%). The effects of adding wage risk to the freeze scenarios are therefore similar to the effects of adding wage risk to the baseline scenarios, albeit slightly smaller in magnitude. Again, at the 90th percentile, a soft-freeze saves no costs relative to the 90th percentile without a soft-freeze as shown in the right-most column of Table 5.

Figure 3 shows the effects in the 10 most populous states of soft and hard freezes under the mean outcome without wage risk, assuming the government must bear the full 12.4% cost for new Social Security enrollees. Broadly speaking, the fewer state employees that are in Social Security, the less the state's benefit costs will decline when there are freezes.

V. Conclusion

This paper proposes an alternative measurement for the quality of public pension funding, namely the extent to which state and local governments will have to raise taxes or cut spending to pay for pension obligations. Specifically, we calculate how much states have to increase revenues or cut spending to pay new pension promises to existing employees and pay down unfunded legacy liabilities over the next 30 years. Given blurred lines between what is a state obligation and what is a local obligation, our analysis considers all state and local government DB plans within a state as a unit, and compares that to all revenue sources of state and local governments within the state.

Most state and local governments in fact use amortization periods of around 30 years for unfunded liabilities. We show that actually achieving fully funded systems in 30 years will require devoting substantially more resources to the systems. Government accounting generally implements this amortization using smoothed asset values, return expectations of around 8%, and the assumption that all future benefit accruals will be fully funded, a set of assumptions that does not imply the state will be at or close to full funding in 30 years.

One theme that emerges is that substantial revenue increases or spending cuts are required to pay for pension promises to public employees even if pension promises are frozen at today's levels. The cost savings that states would realize through soft or hard freezes depends on the current level of generosity of the plans, as well as current levels of employee contributions and the generosity of the DC plan that would replace the DB plan. Hard freezes, even with the more costly DC transition scenario that we model (an employer DC cost of 10% of pay, plus Social Security for all employees fully paid for by the employer), reduce revenue demands for all states. Soft freezes with similar transition modeling reduce revenue demands for all but seven states with relatively large employee contributions and relatively low current Social Security coverage. In four of those states, a soft freeze would be cost saving if employees newly enrolled in Social Security were forced to bear a significant share of that new enrollment. Achieving cost savings under a soft freeze in the remaining states would require less generous DC plans.

A significant finding of our analysis is that the GASB rules significantly undervalue the cost of providing DB plans to state workers, as the true present value of new benefit accruals averages 12-14 percent of payroll more than the costs recognized under GASB. These distortions can generate conflicting interests between state and local governments. For example, in states where the state government is responsible for paying the unfunded liability for plans covering local workers such as teachers GASB accounting forces states to subsidize local government employees. In these situations the state effectively must bear the expense of the extra 12-14 percent of payroll that the plans actually cost, potentially encouraging excessive hiring at the local level. State governments typically bear that burden by taking high levels of investment risk and requiring taxpayers to underwrite downside insurance. Conversely, in some states the state government negotiates the pension benefits of local employees, but requires local governments to fund these benefits, as happens for example with municipal police and fire systems in Illinois. In that case, the state essentially forces the local governments into a similar arrangement.

We have modeled some degree of tax base sensitivity to the required increase in revenues or cuts in spending. An interesting avenue for future research would be to further examine how these effects would operate at the local level, as cities and counties may be more exposed to the threat of citizens "voting with their feet" than states. The extent to which such migration might affect the solvency of local governments is an important area for future research.

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Figure 1. One-Year Change in Recognized Cash Flow Promises for Non-Retiring Workers

This figure provides a graphical representation of how service costs are calculated. The top two lines show the year by year forecast of the expected benefit payments recognized under the EAN (solid line), and those recognized the previous year under the EAN for the same workers (dashed line). The bottom two lines show the expected benefit payments recognized under the ABO (dotted line) and those recognized the previous year under the ABO for the same workers (lowest line). The present value of the difference in the top two lines yields the EAN service cost, and the present value of the difference in the bottom two lines yields the ABO service cost.

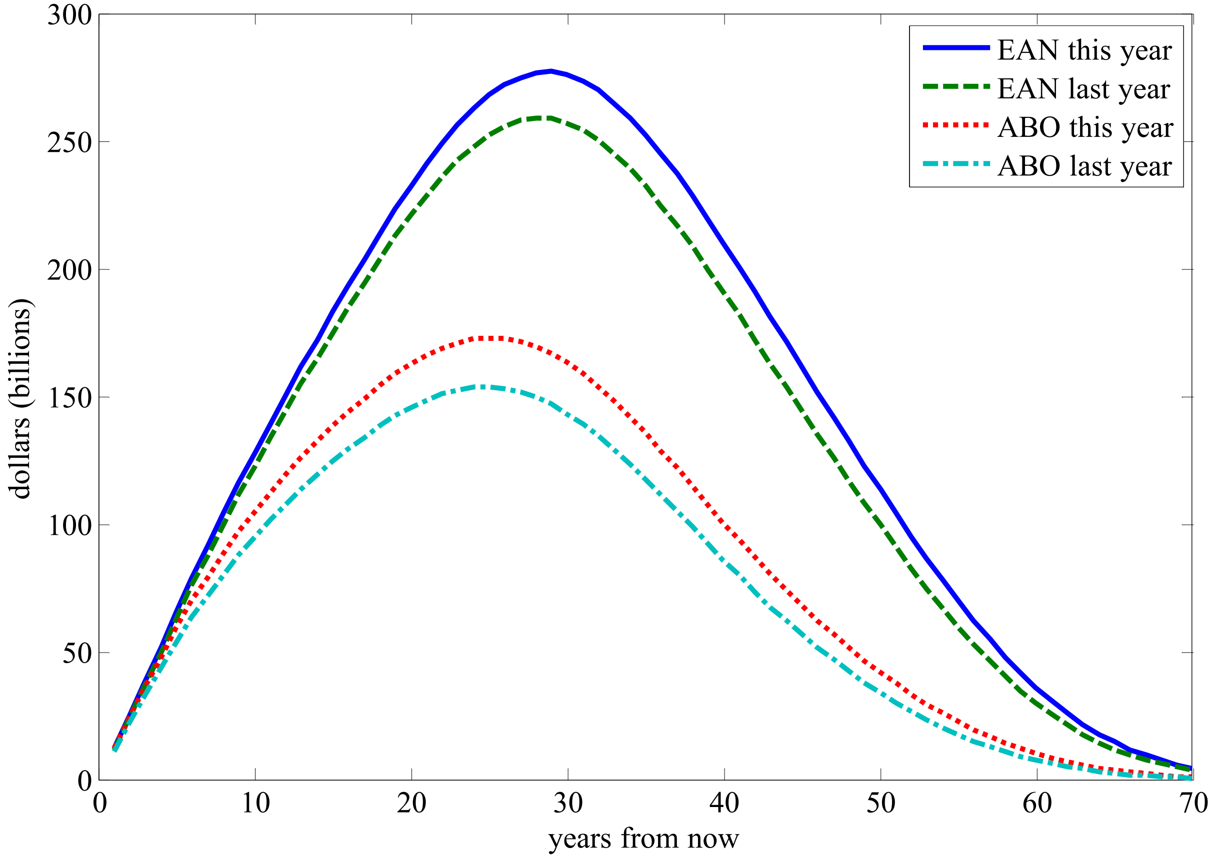
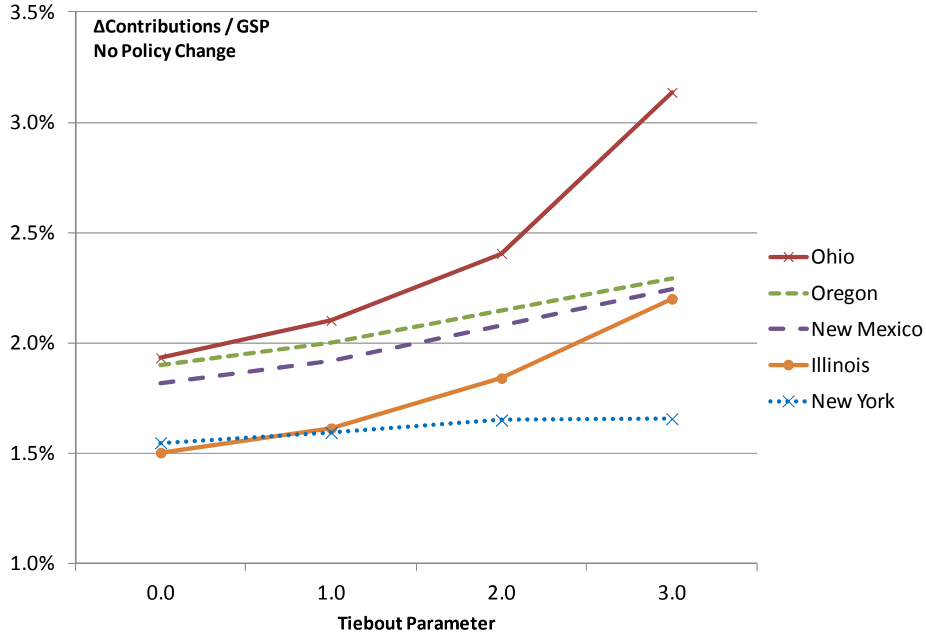


FIGURE 2. EFFECTS OF TIEBOUT PARAMETERS ON REQUIRED CONTRIBUTION INCREASES

The figures show required increase in government contributions as a share of GSP to arrive at a fully funded pension system in 30 years on an ABO basis, assuming no benefit changes, under different Tiebout parameters. In the top figure, only the five states with the largest necessary contribution increases are shown. In the bottom figure, only the five states with the smallest necessary contribution increases are shown. The Tiebout parameter is the decline in the GSP growth rate per additional point of GSP raised in state government revenue.



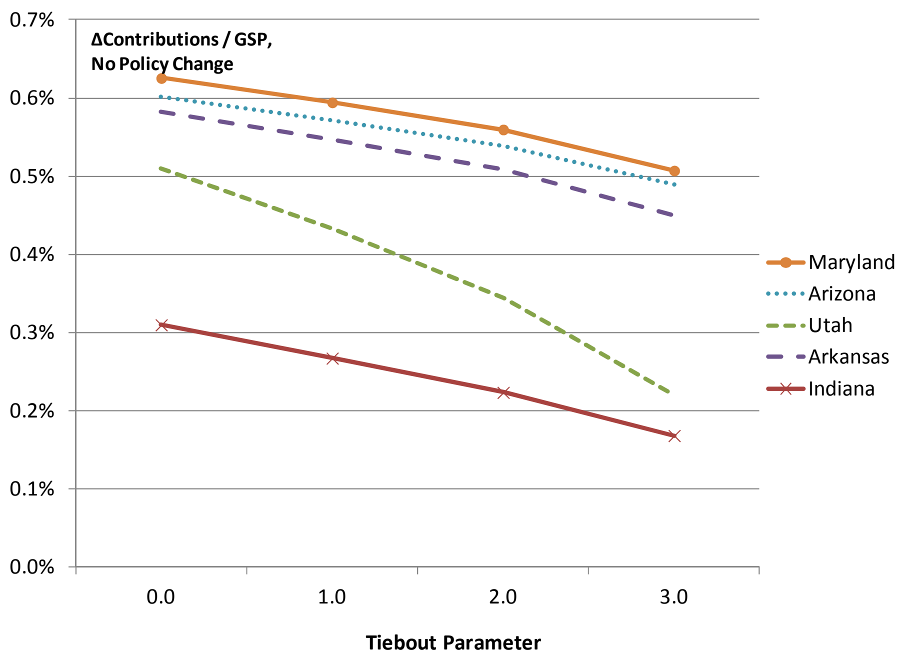


FIGURE 3. EFFECTS OF SOFT AND HARD FREEZES IN MOST POPULOUS STATES

The top figure shows the 10 most populous states in descending order of per household required contribution increases if there are no policy changes. The effects of soft and hard freezes are shown assuming that the government would have to bear the full cost of new social security entrants. The bottom figure shows analogous calculations for the same states in descending order of the required contribution increase as a percent of payroll.

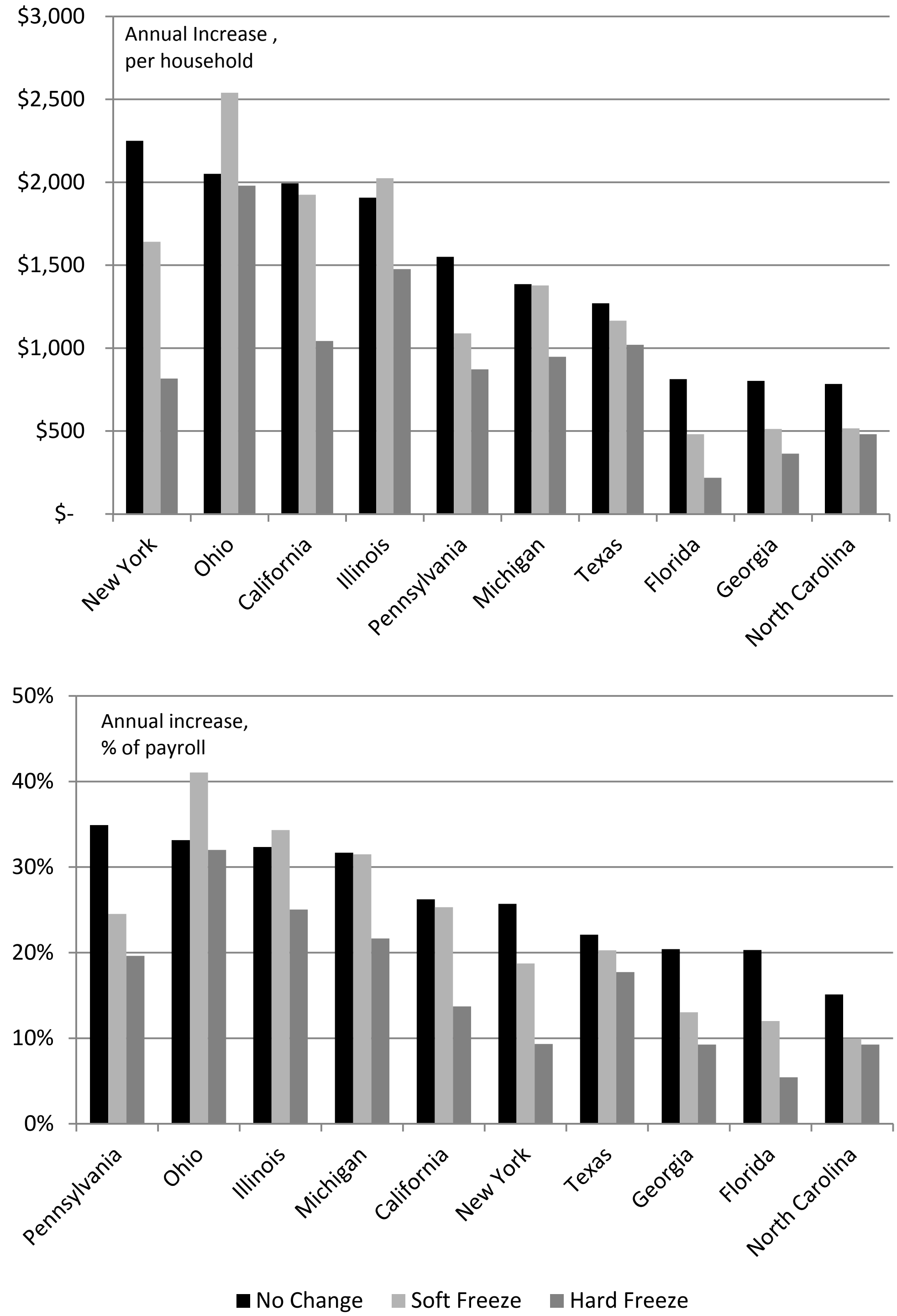


TABLE 1—SUMMARY STATISTICS: CONTRIBUTIONS, PAYROLL, AND REVENUES (2009) FOR STATE AND LOCAL SYSTEMS, AGGREGATED TO THE STATE LEVEL

	mean	std dev	total	min		max	
Tax Revenue	$24.3	$30.8	$1,215.1	$2.5	SD	$160.1	CA
Total Own Revenue	$38.9	$47.9	$1,947.4	$4.3	SD	$262.0	CA
Gross State Product (GSP)	$281.0	$337.5	$14,051.7	$25.4	VT	$1,891.4	CA
Households (M)	2.36	2.62	117.85	0.21	WY	14.22	CA
Payroll							
$ billions	$13.6	$18.6	$678.4	$1.2	VT	$108.1	CA
as share of Tax Revenue	54.3%	10.4%	55.8%	35.3%	NE	79.2%	AL
as share of Total Own Revenue	32.9%	5.7%	34.8%	17.4%	NE	42.5%	TX
as share of Gross State Product	4.6%	0.8%	4.8%	2.9%	NE	6.2%	NM
per household	$5,450	$1,310	$5,757	$3,507	AR	$8,772	WY
Total Government Contributions (Including Social Security)							
$ billions	$2.2	$3.3	$110.9	$0.2	ND	$19.5	CA
as share of Payroll	16.5%	3.9%	16.3%	9.0%	TX	26.7%	RI
as share of Tax Revenue	8.9%	2.6%	9.1%	4.7%	ND	14.8%	AL
as share of Total Own Revenue	5.4%	1.6%	5.7%	2.8%	CO	9.3%	RI
as share of Gross State Product	0.8%	0.2%	0.8%	0.4%	CO	1.3%	RI
per household	$892	$280	$941	$463	CO	$1,739	NY
Total Government Contributions (Excluding Social Security)							
$ billions	$1.6	$2.5	$80.7	$0.1	ND	$15.2	CA
as share of Payroll	11.6%	4.3%	11.9%	3.3%	NC	22.4%	NV
as share of Tax Revenue	6.3%	2.5%	6.6%	2.1%	NC	12.1%	NV
as share of Total Own Revenue	3.8%	1.6%	4.1%	1.3%	NC	7.6%	NV
as share of Gross State Product	0.5%	0.2%	0.6%	0.2%	NC	1.0%	RI
per household	$628	$275	$684	$173	NC	$1,291	NY
Total Employee Contributions (Including Social Security)							
$ billions	$1.4	$1.9	$69.1	$0.1	VT	$12.6	CA
as share of Payroll	10.6%	2.6%	10.2%	2.6%	NV	15.2%	NM
as share of Tax Revenue	5.8%	2.0%	5.7%	1.4%	NV	10.7%	NM
as share of Total Own Revenue	3.5%	1.1%	3.5%	0.9%	NV	6.0%	NM
as share of Gross State Product	0.5%	0.2%	0.5%	0.1%	NV	0.9%	NM
per household	$577	$185	$586	$135	NV	$1,006	WY
Total Employee Contributions (Excluding Social Security)							
$ billions	$0.8	$1.3	$38.8	$0.0	OR	$8.3	CA
as share of Payroll	5.8%	2.5%	5.7%	0.1%	OR	11.2%	MA
as share of Tax Revenue	3.1%	1.5%	3.2%	0.1%	OR	6.5%	OH
as share of Total Own Revenue	1.9%	0.9%	2.0%	0.0%	OR	4.1%	OH
as share of Gross State Product	0.3%	0.1%	0.3%	0.0%	OR	0.6%	OH
per household	$312	$154	$330	$6	OR	$644	AK

TABLE 2—SERVICE COSTS AS PERCENT OF PAYROLL, STATE AND LOCAL AGGREGATED TO STATE LEVEL

This table provides the service costs for each state under each of the two liability recognition methods (Entry Age Normal (EAN) and Accumulated Benefit Obligation (ABO)) as well under each of two discounting methodologies (the state-chosen rate and Treasury yield curves). Each row represents the total of all state and local government systems within a given state. The ABO is often referred to as the "termination liability," because it recognizes only the portion of expected future pension benefits payments due to an employee's current wages and service. The EAN recognizes future liabilities in proportion to the ratio of the present value of a worker's wages earned to date and the present value of lifetime wages, which leads to service accruals that are a constant fraction of an employee's wages throughout the employee's career. The discounting under the Treasury yield curve is achieved by deflating nominal cash flows at the inflation rate and discounting the resulting real cash flow stream using the December 2010 zero-coupon TIPS yield curve.

	ABO Service Cost		EAN Service Cost		Actual Contributions		Cost / Contribution	
	Stated	Treasury	Stated	Treasury	Employee	Total	ABO	EAN
	(1)	(2)	(3)	(4)	(5)	(6)	(2)/(6)	(4)/(6)
Oregon	14.8%	30.4%	9.8%	28.5%	0.1%	8.4%	3.6	3.4
Wyoming	17.7%	30.3%	14.2%	29.2%	5.3%	10.3%	2.9	2.8
Delaware	15.4%	23.1%	13.0%	22.3%	2.4%	8.3%	2.8	2.7
North Dakota	17.7%	26.9%	14.7%	25.9%	4.7%	11.3%	2.4	2.3
Pennsylvania	18.2%	32.3%	14.6%	31.2%	7.0%	13.9%	2.3	2.2
North Carolina	16.6%	22.1%	14.6%	21.4%	6.2%	9.6%	2.3	2.2
Wisconsin	16.3%	25.9%	13.0%	24.7%	6.4%	11.6%	2.2	2.1
Minnesota	14.0%	26.5%	9.9%	25.1%	5.4%	11.9%	2.2	2.1
Vermont	14.5%	26.2%	11.1%	25.1%	4.8%	11.8%	2.2	2.1
Texas	18.2%	28.7%	15.0%	27.7%	6.0%	13.1%	2.2	2.1
Utah	18.3%	32.5%	14.1%	31.1%	0.9%	15.0%	2.2	2.1
New Jersey	15.1%	28.7%	10.8%	27.2%	6.2%	13.4%	2.1	2.0
Colorado	22.0%	40.8%	15.2%	38.5%	8.5%	19.8%	2.1	1.9
Washington	16.7%	26.5%	13.5%	25.5%	4.2%	12.9%	2.1	2.0
Kansas	14.5%	22.6%	12.0%	21.9%	4.1%	11.5%	2.0	1.9
Tennessee	16.3%	25.7%	12.8%	24.5%	3.1%	13.9%	1.8	1.8
New York	16.9%	30.4%	12.8%	29.1%	1.9%	16.6%	1.8	1.7
Nebraska	19.3%	32.4%	14.5%	30.8%	7.3%	17.9%	1.8	1.7
Iowa	14.9%	22.1%	12.4%	21.3%	4.6%	12.2%	1.8	1.7
South Dakota	15.9%	24.1%	12.8%	23.1%	6.5%	13.5%	1.8	1.7
Florida	15.3%	26.3%	11.9%	25.2%	1.4%	14.9%	1.8	1.7
New Hampshire	12.5%	23.7%	9.5%	22.8%	5.8%	14.0%	1.7	1.6
Georgia	18.5%	26.0%	15.8%	25.1%	4.5%	15.5%	1.7	1.6
New Mexico	23.0%	37.5%	17.9%	35.9%	9.0%	22.6%	1.7	1.6
Idaho	19.4%	28.3%	16.3%	27.4%	6.4%	17.1%	1.7	1.6
Kentucky	19.8%	28.1%	17.0%	27.2%	6.8%	17.5%	1.6	1.6
Ohio	21.2%	33.7%	16.7%	32.3%	10.2%	21.5%	1.6	1.5
California	20.4%	34.8%	15.3%	33.0%	7.8%	22.2%	1.6	1.5
Michigan	14.6%	24.0%	11.3%	22.9%	3.4%	15.3%	1.6	1.5
Missouri	19.9%	33.6%	15.4%	32.1%	7.1%	21.6%	1.6	1.5
Alaska	19.4%	33.5%	14.5%	31.9%	7.6%	22.1%	1.5	1.4
Montana	16.2%	28.6%	12.1%	27.2%	8.8%	19.0%	1.5	1.4
Virginia	16.3%	28.7%	12.6%	27.4%	0.8%	19.2%	1.5	1.4
Mississippi	20.0%	29.5%	16.3%	28.3%	7.4%	20.1%	1.5	1.4
Nevada	23.0%	36.4%	18.9%	35.2%	2.6%	25.0%	1.5	1.4
South Carolina	16.9%	25.7%	14.0%	24.8%	7.3%	18.2%	1.4	1.4
Connecticut	17.4%	26.0%	14.1%	25.0%	4.4%	19.0%	1.4	1.3

Alabama	18.3%	24.7%	15.8%	23.9%	5.6%	18.0%	1.4	1.3
Maryland	17.9%	25.8%	14.5%	24.7%	5.6%	18.9%	1.4	1.3
Oklahoma	18.3%	31.5%	14.3%	30.1%	6.8%	23.8%	1.3	1.3
Arizona	16.7%	22.8%	14.6%	22.2%	8.1%	17.4%	1.3	1.3
Hawaii	12.1%	22.6%	8.7%	21.4%	4.5%	17.4%	1.3	1.2
Louisiana	19.6%	34.0%	15.6%	32.8%	8.8%	26.3%	1.3	1.2
Arkansas	15.6%	24.1%	12.1%	22.9%	4.9%	18.7%	1.3	1.2
Maine	22.6%	30.1%	18.7%	28.8%	7.5%	23.5%	1.3	1.2
Rhode Island	21.4%	36.3%	16.8%	34.8%	8.7%	29.1%	1.2	1.2
Massachusetts	18.5%	32.7%	13.4%	31.3%	11.2%	26.6%	1.2	1.2
Illinois	18.4%	31.5%	14.0%	30.1%	8.4%	26.6%	1.2	1.1
West Virginia	18.0%	28.7%	14.8%	27.6%	7.7%	25.6%	1.1	1.1
Indiana	12.4%	16.6%	10.4%	16.0%	3.1%	17.2%	1.0	0.9
Overall	17.8%	29.5%	13.9%	28.2%	5.8%	17.7%	1.7	1.6

TABLE 3—NECESSARY CONTRIBUTIONS AND CONTRIBUTION INCREASES FOR FULL FUNDING IN 30 YEARS WITHOUT POLICY CHANGES

		Total Required Contribution				Required Increase Above Current Rates			
		ABO, 10yr Average State GSP Growth		ABO, 10yr Average GSP Growth - 1%		ABO, 10yr Average State GSP Growth		ABO, 10yr Average GSP Growth - 1%	
Contributions / Payroll	Weighted Average	40.4%		42.5%		24.1%		26.1%	
	Mean, StDev	38.3%	(6.6%)	40.2%	(7.3%)	21.8%	(6.8%)	23.7%	(7.4%)
	Min, Max	24.7%	53.9%	25.1%	58.6%	7.5%	42.5%	8.8%	46.1%
	Min State, Max State	NC	CO	NC	IL	IN	CO	IN	CO
Contributions / Tax Revenue	Weighted Average	22.6%		23.7%		13.4%		14.6%	
	Mean, StDev	20.8%	(5.4%)	21.8%	(5.8%)	11.8%	(4.4%)	12.9%	(4.8%)
	Min, Max	12.2%	34.6%	12.9%	36.2%	3.6%	24.7%	4.2%	26.3%
	Min State, Max State	AK	OR	ND	OR	IN	OR	IN	OR
Contributions / Total Own Revenue	Weighted Average	14.1%		14.8%		8.4%		9.1%	
	Mean, StDev	12.6%	(3.2%)	13.2%	(3.4%)	7.2%	(2.6%)	7.8%	(2.9%)
	Min, Max	6.4%	20.2%	7.0%	22.3%	2.2%	13.4%	2.6%	14.7%
	Min State, Max State	AK	IL	AK	IL	IN	OH	IN	OH
Contributions / GSP	Weighted Average	2.0%		2.1%		1.2%		1.3%	
	Mean, StDev	1.8%	(0.5%)	1.9%	(0.5%)	1.0%	(0.4%)	1.1%	(0.4%)
	Min, Max	1.1%	3.0%	1.1%	3.2%	0.3%	1.9%	0.4%	2.1%
	Min State, Max State	DE	NM	DE	NM	IN	OH	IN	OH
Contributions / Household	Weighted Average	$2,326		$2,445		$1,385		$1,504	
	Mean, StDev	$2,089	($623)	$2,193	($665)	$1,197	($482)	$1,301	($521)
	Min, Max	$1,211	$3,989	$1,267	$4,157	$329	$2,250	$385	$2,419
	Min State, Max State	IN	NY	IN	NY	IN	NY	IN	NY

TABLE 4—REQUIRED INCREASES FOR FULL FUNDING BY STATE, NO POLICY CHANGE

This table shows required contribution increases by state, in descending order of the required increase per resident household. Columns on the right display the increase required to pay only the present value of new accruals.

	For Full Funding in 30 Years						For Service Costs Only	
	$ Billions	% Payroll	% Tax Revenue	% Own Revenue	% GSP	per household	$ Billions	per household
New York	$16.9	25.7%	12.3%	8.6%	1.5%	$2,250	$9.1	$1,208
Oregon	$3.1	36.1%	24.7%	13.2%	1.9%	$2,140	$1.9	$1,303
Wyoming	$0.4	23.7%	10.3%	6.5%	1.2%	$2,080	$0.4	$1,748
Ohio	$9.1	33.2%	21.3%	13.4%	1.9%	$2,051	$3.4	$760
New Jersey	$6.7	24.9%	14.1%	10.2%	1.4%	$2,000	$3.2	$966
California	$28.3	26.2%	17.7%	10.8%	1.5%	$1,994	$14.0	$988
Minnesota	$3.9	28.9%	16.9%	11.0%	1.5%	$1,928	$2.0	$971
Illinois	$9.5	32.3%	17.8%	12.3%	1.5%	$1,907	$1.9	$382
New Mexico	$1.4	29.1%	20.4%	11.4%	1.8%	$1,756	$0.7	$900
Colorado	$3.4	42.5%	19.0%	10.6%	1.3%	$1,739	$1.7	$858
Pennsylvania	$7.5	34.9%	14.8%	9.7%	1.4%	$1,550	$4.0	$818
Wisconsin	$3.3	27.0%	14.2%	9.3%	1.4%	$1,522	$1.8	$807
Connecticut	$2.0	22.1%	9.6%	7.5%	0.9%	$1,459	$0.6	$462
Michigan	$5.3	31.7%	15.4%	9.3%	1.4%	$1,386	$1.5	$379
Washington	$3.5	20.8%	13.5%	7.4%	1.0%	$1,371	$2.4	$919
Alaska	$0.4	15.9%	6.4%	3.4%	0.8%	$1,356	$0.2	$777
Hawaii	$0.6	17.2%	10.4%	6.9%	1.0%	$1,288	$0.2	$387
Texas	$12.1	22.1%	15.4%	9.4%	1.1%	$1,271	$8.6	$905
Missouri	$2.9	26.9%	15.5%	9.7%	1.2%	$1,264	$1.3	$563
Kentucky	$2.1	26.4%	15.2%	9.4%	1.3%	$1,260	$0.8	$505
Delaware	$0.4	19.5%	11.6%	6.1%	0.7%	$1,210	$0.3	$917
Kansas	$1.3	19.2%	11.7%	7.1%	1.0%	$1,197	$0.8	$693
Massachusetts	$3.0	21.7%	9.9%	6.4%	0.8%	$1,190	$1.0	$389
South Carolina	$2.1	23.5%	17.7%	7.9%	1.3%	$1,186	$0.7	$380
Vermont	$0.3	23.2%	9.6%	6.5%	1.1%	$1,163	$0.2	$721
Mississippi	$1.3	21.8%	14.5%	8.2%	1.3%	$1,127	$0.6	$484
Louisiana	$1.9	21.9%	11.8%	7.3%	0.9%	$1,118	$0.7	$394
Virginia	$3.2	18.5%	11.1%	6.8%	0.8%	$1,066	$1.7	$550
North Dakota	$0.3	21.3%	7.8%	5.0%	0.8%	$1,042	$0.2	$764
New Hampshire	$0.5	20.6%	11.0%	6.8%	0.9%	$1,010	$0.2	$476
Nevada	$0.9	17.2%	9.3%	5.9%	0.7%	$884	$0.6	$586
Nebraska	$0.6	24.3%	8.6%	4.2%	0.7%	$881	$0.4	$529
Montana	$0.3	19.4%	9.7%	5.8%	0.9%	$872	$0.2	$433
Alabama	$1.6	15.4%	12.2%	6.1%	0.9%	$868	$0.7	$373
Iowa	$1.0	15.4%	8.5%	5.0%	0.7%	$861	$0.6	$551
Oklahoma	$1.2	19.3%	10.0%	5.9%	0.8%	$850	$0.5	$340
Tennessee	$2.0	20.8%	11.8%	5.8%	0.8%	$837	$1.1	$473
Maryland	$1.8	15.6%	6.7%	4.9%	0.6%	$818	$0.8	$362
Florida	$5.8	20.3%	8.9%	5.3%	0.8%	$813	$3.4	$473
Rhode Island	$0.3	13.9%	7.2%	4.8%	0.7%	$810	$0.0	$4
Georgia	$3.0	20.4%	10.1%	6.1%	0.8%	$803	$1.6	$412
North Carolina	$2.8	15.1%	9.5%	5.7%	0.7%	$784	$2.3	$649
South Dakota	$0.2	15.9%	9.6%	5.7%	0.6%	$776	$0.2	$518
Maine	$0.4	18.7%	7.1%	4.9%	0.8%	$761	$0.1	$268
Idaho	$0.4	16.5%	10.2%	6.0%	0.8%	$737	$0.3	$501
Arizona	$1.5	11.6%	7.8%	4.7%	0.6%	$608	$0.7	$281
West Virginia	$0.4	14.7%	6.7%	4.1%	0.7%	$600	$0.1	$125
Utah	$0.6	13.2%	6.9%	3.6%	0.5%	$538	$0.2	$166
Arkansas	$0.6	15.2%	6.4%	4.1%	0.6%	$534	$0.2	$187
Indiana	$0.8	7.5%	3.6%	2.2%	0.3%	$329	-$0.1	($23)
Total	$163.2	24.1%	13.4%	8.4%	1.2%	$1,385	$79.6	$676

TABLE 5—REQUIRED CONTRIBUTION INCREASES UNDER DIFFERENT SCENARIOS

		Risk-Neutral Asset Return											
		Mean				10th Percentile				90th Percentile			
	Future Wage Risk (ρ)	0.00		0.25		0		0.25		0		0.25	
Contributions/	Weighted Avg	24.1%		22.5%		42.9%		39.3%		13.1%		12.7%	
Payroll	Mean, StDev	21.8%	(6.8%)	20.4%	(6.6%)	38.7%	(10.4%)	35.4%	(9.7%)	11.9%	(5.4%)	11.5%	(5.3%)
	Min, Max	7.5%	42.5%	6.7%	40.2%	18.8%	67.5%	16.9%	62.0%	1.1%	28.3%	0.8%	27.7%
	Min, Max State	IN	CO	IN	CO	IN	CO	IN	CO	IN	CO	IN	CO
Contributions/	Weighted Avg	13.4%		12.6%		23.9%		21.9%		7.3%		7.1%	
Tax Revenue	Mean, StDev	11.8%	(4.4%)	11.1%	(4.2%)	21.0%	(7.1%)	19.2%	(6.6%)	6.5%	(3.1%)	6.3%	(3.1%)
	Min, Max	3.6%	24.7%	3.2%	23.4%	9.0%	40.5%	8.0%	37.5%	0.5%	15.2%	0.4%	14.8%
	Min, Max State	IN	OR	IN	OR	IN	OR	IN	OR	IN	OR	IN	OR
Contributions/	Weighted Avg	8.4%		7.9%		14.9%		13.7%		4.6%		4.4%	
Own Revenue	Mean, StDev	7.2%	(2.6%)	6.7%	(2.5%)	12.8%	(4.3%)	11.7%	(4.0%)	3.9%	(1.9%)	3.8%	(1.9%)
	Min, Max	2.2%	13.4%	2.0%	12.7%	5.5%	24.2%	4.9%	22.5%	0.3%	8.1%	0.2%	8.0%
	Min, Max State	IN	OH	IN	OH	IN	OH	IN	OH	IN	OR	IN	OR
Contributions/	Weighted Avg	1.2%		1.1%		2.1%		1.9%		0.6%		0.6%	
GSP	Mean, StDev	1.0%	(0.4%)	0.9%	(0.4%)	1.8%	(0.6%)	1.6%	(0.6%)	0.6%	(0.3%)	0.5%	(0.3%)
	Min, Max	0.3%	1.9%	0.3%	1.8%	0.8%	3.5%	0.7%	3.2%	0.0%	1.2%	0.0%	1.1%
	Min, Max State	IN	OH	IN	OH	IN	OH	IN	OH	IN	OR	IN	OR
Contributions/	Weighted Avg	$1,385		$1,298		$2,468		$2,261		$756		$731	
Household	Mean, StDev	$1,197	($482)	$1,121	($459)	$2,112	($765)	$1,932	($707)	$663	($344)	$640	($339)
	Min, Max	$329	$2,250	$294	$2,114	$820	$4,026	$736	$3,703	$46	$1,499	$36	$1,461
	Min, Max State	IN	NY	IN	NY	IN	NY	IN	NY	IN	WY	IN	WY

TABLE 6—EFFECTS OF LIMITS ON DEBT ISSUANCE

This table accounts for variation in municipal indebtedness that affect the ability of governments to issue debt to fund pension liabilities. These effects are modeled as reductions in pension fund assets to reflect the difference between a state's aggregate municipal debt relative to GSP and the ratio of aggregate national municipal debt to national GDP. If a state's aggregate municipal debt relative to GSP exceeds aggregate national municipal debt relative to national GDP, its pension fund assets are reduced to reflect the difference. Conversely, if a state's debt is relatively small relative to its economy, the difference is added to its pension fund assets. See Section III.D for details.

	State and Local Debt		Effect of Debt Restriction on Required Annual Contribution	
	$ billions	% of GSP	as % of GSP	% of own revenue
5 States with Largest Effects of Debt Restrictions				
Kentucky	42.0	27%	0.30%	2.13%
Massachusetts	96.3	26%	0.26%	2.05%
New York	289.6	26%	0.26%	1.43%
Rhode Island	11.7	25%	0.18%	1.29%
South Carolina	36.8	23%	0.15%	0.91%
5 States Most Able to Take Advantage of Debt				
North Dakota	3.3	10%	-0.20%	-1.22%
Georgia	52.0	13%	-0.20%	-1.58%
Arkansas	12.5	12%	-0.20%	-1.43%
Idaho	5.9	11%	-0.22%	-1.60%
Iowa	13.6	10%	-0.27%	-1.91%

TABLE 7—NECESSARY AGGREGATE CONTRIBUTION INCREASES FOR SOFT AND HARD FREEZE, NO WAGE RISK

The table shows the required contribution increases for full funding in 30 years under a soft freeze (Panel A) and a hard freeze (Panel B), assuming no Tiebout effects. In the soft freeze, the DB plan is closed to new hires, and new hires receive a DC plan with a 10% employer contribution, plus Social Security enrolment where employees do not yet participate. In the hard freeze, all accruals are stopped and replaced with the DC plus Social Security prospectively. In the left columns, the 12.4% of payroll cost of Social Security for new entrants is borne entirely by the employer. In the right panel, it is shared equally between employer and employee.

	Cost of Social Security Entrants Borne By					
	Employer			Employer-Employee		
Asset Return	Mean	10th	90th	Mean	10th	90th
Wage Risk (ρ)	0.00	0.00	0.00	0.00	0.00	0.00
Panel A: Soft Freeze						
Δ[Contributions / Payroll]	21.0%	33.0%	13.1%	19.7%	31.6%	11.8%
Δ[Contributions / Tax Revenue]	11.7%	18.4%	7.3%	11.0%	17.6%	6.6%
Δ[Contributions / Own Revenue]	7.3%	11.5%	4.6%	6.9%	11.0%	4.1%
Δ[Contributions / GSP]	1.0%	1.6%	0.6%	1.0%	1.5%	0.6%
Δ[Contributions / Household]	$1,210	$1,901	$753	$1,134	$1,819	$681
Panel B: Hard Freeze						
Δ[Contributions / Payroll]	13.9%	19.5%	9.4%	12.2%	17.7%	7.7%
Δ[Contributions / Tax Revenue]	7.8%	10.9%	5.3%	6.8%	9.9%	4.3%
Δ[Contributions / Own Revenue]	4.8%	6.8%	3.3%	4.2%	6.2%	2.7%
Δ[Contributions / GSP]	0.7%	0.9%	0.5%	0.6%	0.9%	0.4%
Δ[Contributions / Household]	$800	$1,120	$543	$701	$1,021	$444

TABLE 8—NECESSARY AGGREGATE CONTRIBUTION INCREASES FOR SOFT AND HARD FREEZE, WITH WAGE RISK

The table shows the required contribution increases for full funding in 30 years under a soft freeze (Panel A) and a hard freeze (Panel B), assuming no Tiebout effects. In the soft freeze, the DB plan is closed to new hires, and new hires receive a DC plan with a 10% employer contribution, plus Social Security enrolment where employees do not yet participate. In the hard freeze, all accruals are stopped and replaced with the employer DC contributions plus the Social Security contributions. In the left columns, the 12.4% of payroll cost of Social Security for new entrants is borne entirely by the employer. In the right panel, it is shared equally between employer and employee.

	Cost of Social Security Entrants Borne By					
	Employer			Employer-Employee		
Asset Return	Mean	10th	90th	Mean	10th	90th
Wage Risk (ρ)	0.25	0.25	0.25	0.25	0.25	0.25
Panel A: Soft Freeze						
Δ[Contributions / Payroll]	19.8%	30.2%	12.7%	18.5%	32.8%	11.2%
Δ[Contributions / Tax Revenue]	11.1%	16.9%	7.1%	10.3%	18.3%	6.3%
Δ[Contributions / Own Revenue]	6.9%	10.5%	4.4%	6.4%	11.4%	3.9%
Δ[Contributions / GSP]	1.0%	1.5%	0.6%	0.9%	1.6%	0.5%
Δ[Contributions / Household]	$1,140	$1,740	$732	$1,065	$1,890	$646
Panel B: Hard Freeze						
Δ[Contributions / Payroll]	13.9%	19.5%	9.4%	12.2%	17.7%	7.7%
Δ[Contributions / Tax Revenue]	7.8%	10.9%	5.3%	6.8%	9.9%	4.3%
Δ[Contributions / Own Revenue]	4.8%	6.8%	3.3%	4.2%	6.2%	2.7%
Δ[Contributions / GSP]	0.7%	0.9%	0.5%	0.6%	0.9%	0.4%
Δ[Contributions / Household]	$800	$1,120	$543	$701	$1,021	$444

APPENDIX

A. *Contributions to Pension Systems*

The study requires measures of contributions to state and local pension systems from both employees and governments. U.S. Census Bureau (2010a) contains data on total pension contributions to each level of government, decomposed into government contributions and employee contributions. For example, the data show that in California in 2008 there were $6.04 billion in employee contributions to state-sponsored plans, $11.37 billion in government contributions to state-sponsored plans, $1.75 billion in employee contributions to locally-sponsored plans, and $4.39 billion in government contributions to locally-sponsored plans.

Using calculations on contribution growth rates from Novy-Marx and Rauh (2011a), we estimate 2009 contributions based on the growth rate of employee and government contributions in the state plans covered by that study. For example, for California Novy-Marx and Rauh (2011a) found that between 2008 and 2009, employee contributions grew by 7.2% for the funds covered in that study (CalPERS, CalSTRS, and the University of California Retirement Plan), while government contributions shrank by 3.4%, so that total contributions shrank by 0.1%.[30] Applying these growth rates to both the state and local cells for California, we estimate that in California in 2009, there were employee contributions of $6.47 billion to state-sponsored plans and $1.87 billion to locally-sponsored plans. There were government contributions of $10.95 billion to state-sponsored plans and $4.28 billion to locally-sponsored plans. The total government contributions were therefore $15.23 billion (= $10.95 + $4.28) and the total employee contributions were $8.34 billion (=$6.47 + $1.87). These are estimates of total contributions to all DB pension systems sponsored by government entities in the state of California.

When looking at contribution measures in systems that include Social Security, we add 6.2% of payroll to employer (and employee) contributions. For example, given the share of workers in California systems that are in Social Security, we estimate total government contributions including Social Security at $19.46 billion in 2009, as opposed to $15.23 billion excluding Social Security.

[30] Employer contributions to CalPERS shrank from $7.2 billion in 2008 to $6.9 billion in 2009.

B. *Calculating Liability Cash Flows*

A plan's total liability cash flow *t* years in the future, recognized under the accounting methodology $m \in \{abo, pbo, ean, pvb\}$, comes from its promises to current workers, current annuitants, and separated workers not yet receiving benefits,

$$\tilde{B}_t^m = \tilde{B}_t^{active,m} + \tilde{B}_t^{retired} + \tilde{B}_t^{separated}.$$

A plan's total liability *t* years in the future due to its promises to its current workers is given by

$$\tilde{B}_t^{active,m} = \sum_{a=R_1-t+1}^{R_F} \sum_{s=1}^{a-a_{\min}+1} \sum_{r=0}^{t-1} N_{a,s} \mu_{a,a+r} S_{a,a+t} b_{a,s,r,t}^m$$

where R_1 is the first age at which workers can start taking benefits (typically assumed to be 55), R_{F} is the age of forced retirement (typically assumed to be 75), $a_{\min}$ is the age of the youngest workers typically assumed to be 21), $N_{a,s}$ is the number of workers of age *a* with *s* years of service, $\mu_{a,a+r}$ is the fraction of workers of age *a* separating in *r* years, $S_{a,a+t}$ is the fraction of workers of age *a* surviving to age *a* + *t* (gender specific, and accounting for survivor benefits when applicable), and $b_{a,s,r,t}^m$ is the average benefit payment *t* years in the future recognized under the accounting methodology *m* to a worker of age *a* with *s* years of service that separates in *r* years.

The benefit payments recognized under the ABO is given by

$$b_{a,s,r,t}^{abo} = \mathbf{1}_{s \geq v} \lambda_{a+r} s \alpha_f w_{a,s} \left(1 + COLA\right)^{t - \max\{r, R_1 - a\}}$$

where $\mathbf{1}_{s \geq v}$ is an indicator variable that accounts for the *v* year vesting period (typically assumed to be five years), $\lambda_{a+r} = 1 - BOR \times \min\left\{R_2 - R_1, \max\left\{R_2 - \left(a + r\right), 0\right\}\right\}$ and reflects the reduction in benefits (*BOR*, typically assumed to be 6%/year) made to workers that start taking benefits before the age of full retirement (R_2, typically assumed to be 60), under the assumption that separated workers begin taking retirement benefits as soon as they are eligible to do so because the buyout rate schedules employed by state and local retirement plans make early retirement actuarially favorable to workers, α_f is the benefit factor, and $w_{a,s}$ is the average salary of a worker of age *a* with *s* years of service, and the last factor accounts for the fact that the COLAs only apply after a worker starts taking benefits, which happens after separation or when a worker reaches age R_1, whichever comes later.

The benefit payments recognized under the other accounting methodologies are given by

$$b^m_{a,s,r,t} = \phi^m_{a,s,r} \mathbf{1}_{s+r \geq v} \lambda_{a+r} \left(s+r\right) \alpha_f \left(\prod_{i=1}^{r} \left(1+g_{a+i}\right) \right) w_{a,s} \left(1+COLA\right)^{t-\max\{r,R_1-a\}}$$

where g_a is the rate of wage growth for a worker of age *a*, and $\phi^m_{a,s,r}$ is the fraction of total benefit payments to a worker of age *a* with *s* years of service separating in *r* years recognized under the accounting methodology *m*. For the PVB, which fully recognizes benefit payments, $\phi^{pvb}_{a,s,r} = 1$; for the PBO, which recognizes the benefit payments in proportion to the fraction of lifetime service performed to date, $\phi^{pbo}_{a,s,r} = \frac{s}{s+r}$; and for the EAN, which recognizes the benefit payments in proportion to the fraction of discounted lifetime wages earned to date,

$$\phi^{ean}_{a,s,r} = \frac{\sum_{i=1}^{s} S_{a-s,a-s+i} \left(1+r_d\right)^{-i} \prod_{j=1}^{i-1} \left(1+g_{a-s+j}\right)}{\sum_{i=1}^{s+r} S_{a-s,a-s+i} \left(1+r_d\right)^{-i} \prod_{j=1}^{i-1} \left(1+g_{a-s+j}\right)}$$

where r_d is the rate used to discount cash flows.

A plan's total liability *t* years in the future due to its promises to its current annuitants is given by

$$\tilde{B}^{retired}_t = \sum_{a=a^A_{\min}}^{a^A_{\max}} N^A_a S_{a,a+t} A_a \left(1+COLA\right)^t$$

where $a^A_{\min}$ and $a^A_{\max}$ are the minimum and maximum age of current annuitants (typically assumed to be 45 and 95, respectively), N^A_a is the number of annuitants of age *a*, and A_a if the average benefit annual benefit payment to annuitants of age *a*.

A plan's total liability t years in the future due to separated vested workers not yet receiving benefits is given by

$$\tilde{B}_t^{separated} = \sum_{s=v}^{s_{\max}} \sum_{a=a_{\min}+s}^{R_1} N_{a,s}^S S_{a,a+t} \lambda_0 s b_f w_{a,s}^S \left(1+COLA\right)^{t-(R_1-a)}$$

where $N_{a,s}^S$ is the number of separated vested workers not yet receiving benefits of age a with service s, and $w_{a,s}^S$ is these workers' average benefits eligible salary.

Total liability cash flows are calibrated to a plan's stated liability using a geometric series

$$B_t^m = \left(1+\lambda\right)^{t-1} \tilde{B}_t^m,$$

where λ is picked such that the calibrated cash flows, recognized under the accounting methodology employed by the state and discounted at the state chosen discount rate, yields the plan's stated liability. That is, λ is chosen to satisfy

$$\sum_{t=1}^{\infty} \frac{\left(1+\lambda\right)^{t-1} \tilde{B}_t^{m_{stated}}}{\left(1+r_{stated}\right)^t} = L_{stated}$$

where m_{stated}, r_{stated} and L_{stated} are the plan's stated accounting methodology, discount rate and liability, respectively.

C. *Normal Costs*

In order to calculate the cost of new benefit accruals, or normal cost, we first determine the expected one year change in the benefit payments recognized under each accounting methodology

$$\Delta\tilde{B}_t^{active,m} = \left(\sum_{a=R_1-t+1}^{R_F} \sum_{s=1}^{a-a_{\min}+1} \sum_{r=1}^{t-1} N_{a,s} \mu_{a,a+r} S_{a,a+t} \Delta b_{a,s,r,t}^m \right) + \tilde{B}_t^{new\_hires,m}$$

where

$$\Delta b_{a,s,r,t}^m = \omega_{a,s} b_{a+1,s+1,r-1,t-1}^m - b_{a,s,r,t}^m$$

and we assume that either wages for workers of a given age and tenure grow at the rate of inflation $\omega_{a,s} = 1+i$ where *i* is the plan's inflation rate assumption, or that wages for workers of age a grow at the rate g_a so that $\omega_{a,s} = (1+g_a)w_{a,s} / w_{a+1,s+1}$, and

$$\tilde{B}_t^{new\_hires,m} = \sum_{a=R_1-t+1}^{R_F} \sum_{r=0}^{t-1} N_a^{new\_hires} \mu_{a,a+r} S_{a,a+t} (1+i) b_{a,1,r,t}^m$$

where we assume that new workers with no previous service are hired to replace those that retire, and that new hires have the same age distribution as current workers in their first year of service,

$$N_a^{new\_hires} = N_{a,1} \left(\sum_{a'=a_{\min}}^{R_F} \sum_{s=1}^{a'-a_{\min}+1} N_{a',s} \mu_{a',a'} \right) / \left(\sum_{a'=a_{\min}}^{R_F} N_{a',1} \right).$$

We calibrate the change in the benefit payments using the same adjustment factor used to calibrate the currently recognized benefits, $\Delta B_t^{active,m} = (1-\lambda)^{t-1} \Delta\tilde{B}_t^{active,m}$. The normal cost is the present value of the increase in the calibrated recognized benefits,

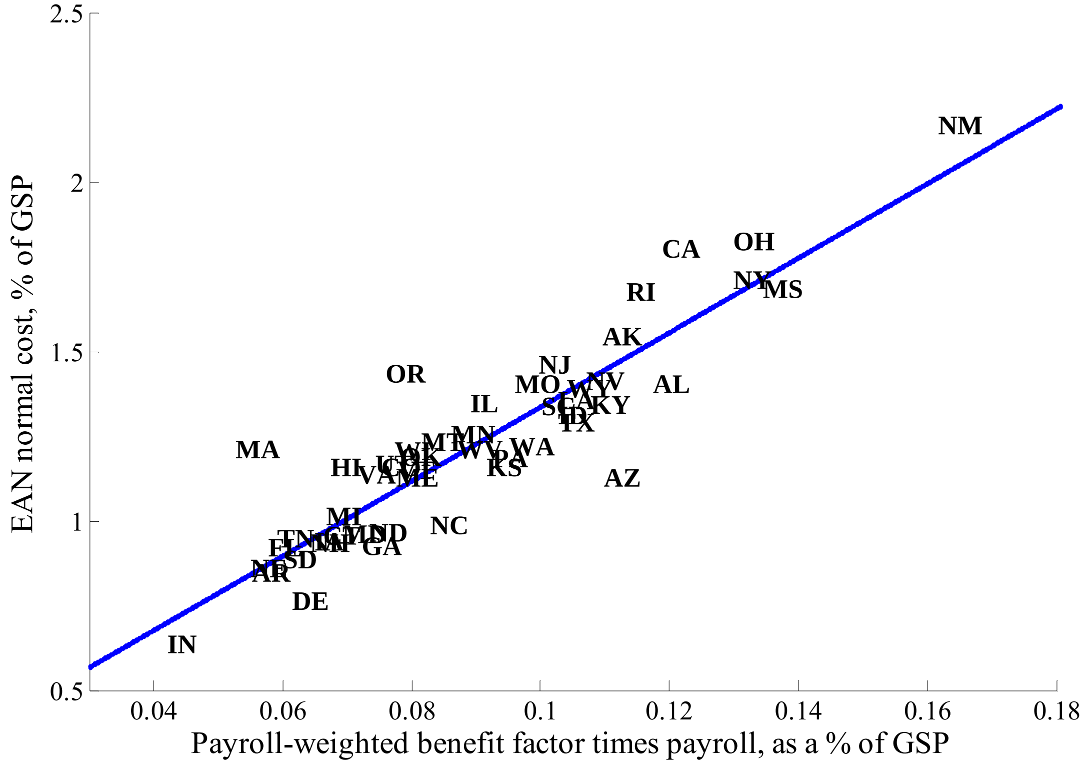
$$NC^m = \sum_{t=2}^{\infty} (1-r_t)^{-t} \Delta B_t^{active,m}$$

where r_t is the discount rate used to discount year *t* cash flows.

D. *Harmonizing Inflation Rate Assumptions*

Each plan's liability cash flows, as well as the expected cost of new benefit accruals, are reforecast under a uniform inflation assumption. This is done using the methodology described above, with two important modifications. First, we reduce the wage growth assumption for workers of every age by 1.36% per year, the difference between the liability-weighted average plan inflation assumption and the Cleveland Fed's forecast of 2% per year. Second, we reduce the COLA applicable to post retirement benefit payments by the difference between the plan specific inflation rate assumption and the Cleveland Fed's forecast. We calibrate these cash flows using the geometric series retained from the calculations employing the plan specific inflation assumptions.

FIGURE A1. SERVICE COST AS A PERCENT OF PAYROLL AND BENEFIT FACTORS



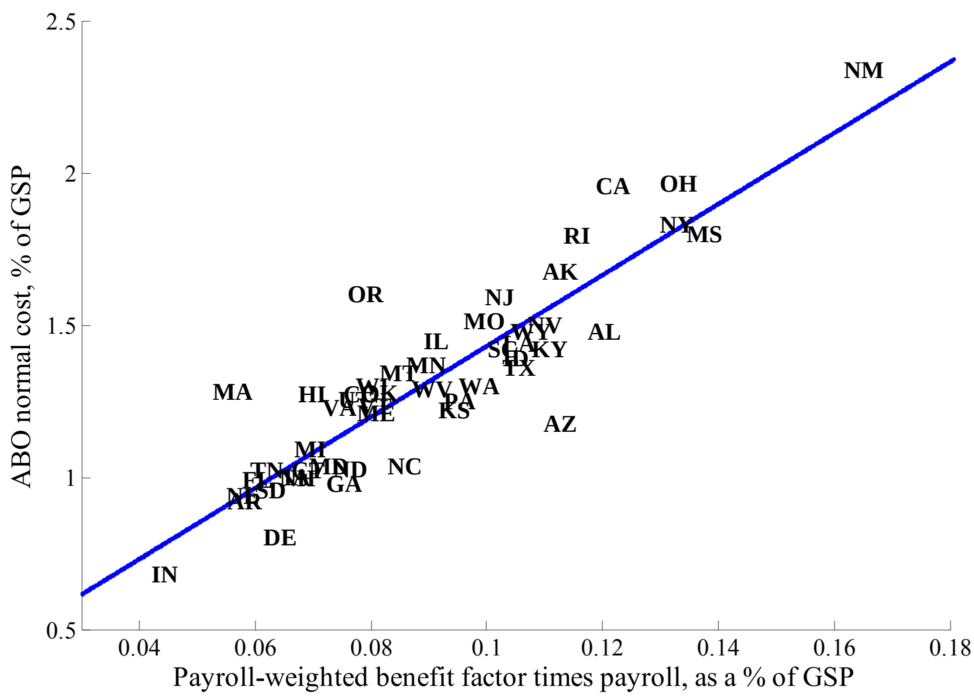


FIGURE A2. PENSION DEBT AND NON-PENSION DEBT ARE COMPLEMENTS

The horizontal axis is total municipal debt as recognized in the U.S. Census of Governments, as a percentage of GSP. The vertical axis is the gap between assets and the present value of liabilities on an ABO basis. Each additional dollar in municipal debt is associated with an additional 67 cents in ABO pension underfunding, and this relation has a t-statistic of 3.61.

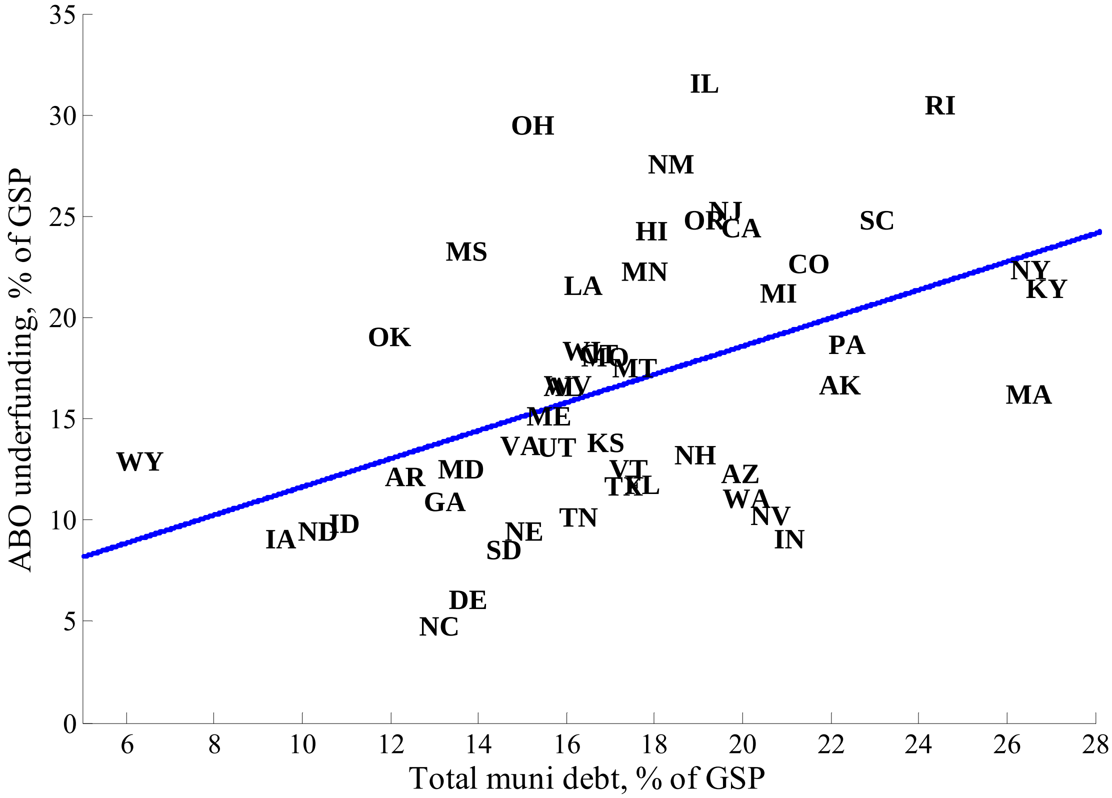


TABLE A1—CONTRIBUTIONS, PAYROLL, AND REVENUES FOR STATE AND LOCAL SYSTEMS,

	Total Payroll ($B)	Own Revenue ($B)	GSP ($B)	Government Contributions Incl Social Security % of Payroll	% Own Revenues	% of GSP	per household
New York	$65.8	$197.7	$1,093.2	19.9%	6.6%	1.2%	$1,738.8
Rhode Island	$2.4	$6.8	$47.8	26.7%	9.3%	1.3%	$1,557.3
Hawaii	$3.7	$9.3	$66.4	19.1%	7.7%	1.1%	$1,436.4
Virginia	$17.5	$47.4	$408.4	23.8%	8.8%	1.0%	$1,374.0
California	$108.1	$262.0	$1,891.4	18.0%	7.4%	1.0%	$1,368.8
Alaska	$2.3	$10.8	$45.7	14.5%	3.1%	0.7%	$1,234.7
Illinois	$29.3	$76.8	$630.4	20.6%	7.9%	1.0%	$1,215.3
New Mexico	$4.7	$11.9	$74.8	19.8%	7.8%	1.2%	$1,194.0
Connecticut	$9.0	$26.2	$227.4	17.8%	6.1%	0.7%	$1,180.6
Nevada	$5.2	$15.3	$126.5	22.4%	7.6%	0.9%	$1,147.2
New Jersey	$26.9	$65.5	$483.0	13.4%	5.5%	0.7%	$1,078.0
Alabama	$10.2	$25.6	$169.9	18.7%	7.4%	1.1%	$1,050.8
Maryland	$11.5	$36.9	$286.8	19.5%	6.1%	0.8%	$1,026.0
Oklahoma	$6.3	$20.4	$153.8	23.2%	7.1%	0.9%	$1,022.2
Wyoming	$1.8	$6.7	$37.5	11.3%	3.1%	0.6%	$987.3
West Virginia	$2.8	$10.2	$63.3	24.1%	6.7%	1.1%	$980.5
Mississippi	$5.9	$15.6	$95.9	18.9%	7.1%	1.2%	$973.0
Washington	$16.9	$47.2	$338.3	14.7%	5.3%	0.7%	$968.3
Louisiana	$8.8	$26.3	$208.4	17.5%	5.9%	0.7%	$891.3
Indiana	$10.8	$37.1	$262.6	20.2%	5.9%	0.8%	$882.1
Massachusetts	$13.5	$46.9	$365.2	16.5%	4.7%	0.6%	$877.6
South Carolina	$8.9	$26.5	$159.6	17.1%	5.7%	0.9%	$862.5
Oregon	$8.7	$23.8	$165.6	14.5%	5.3%	0.8%	$862.1
Kansas	$6.8	$18.4	$124.9	13.6%	5.0%	0.7%	$846.6
Minnesota	$13.5	$35.5	$260.7	12.7%	4.8%	0.7%	$843.8
Utah	$4.4	$15.9	$112.9	20.2%	5.6%	0.8%	$826.9
Arizona	$13.3	$32.6	$256.4	15.3%	6.2%	0.8%	$799.1
Missouri	$10.8	$30.0	$239.8	16.8%	6.0%	0.8%	$787.4
Michigan	$16.8	$56.9	$368.4	17.9%	5.3%	0.8%	$781.3
Florida	$28.6	$109.5	$737.0	19.3%	5.0%	0.7%	$771.8
Iowa	$6.4	$19.8	$142.3	13.8%	4.5%	0.6%	$769.3
Idaho	$2.7	$7.3	$54.0	17.0%	6.1%	0.8%	$757.4
Delaware	$2.1	$6.8	$60.6	12.1%	3.7%	0.4%	$748.7
Montana	$1.7	$5.6	$36.0	16.4%	4.9%	0.8%	$737.6
New Hampshire	$2.5	$7.6	$59.4	14.4%	4.7%	0.6%	$706.2
Arkansas	$3.9	$14.5	$101.8	20.1%	5.4%	0.8%	$703.9
Ohio	$27.5	$67.8	$471.3	11.3%	4.6%	0.7%	$697.1
Kentucky	$7.9	$22.3	$156.6	14.4%	5.1%	0.7%	$685.1
Tennessee	$9.8	$34.8	$244.5	16.7%	4.7%	0.7%	$674.2
Georgia	$14.9	$49.6	$395.2	17.0%	5.1%	0.6%	$669.3
Vermont	$1.2	$4.3	$25.4	13.2%	3.7%	0.6%	$659.3
Maine	$2.1	$7.9	$51.3	16.1%	4.2%	0.6%	$655.0
Wisconsin	$12.3	$35.6	$244.4	11.4%	3.9%	0.6%	$641.3
South Dakota	$1.5	$4.3	$38.3	13.1%	4.7%	0.5%	$639.7
North Dakota	$1.2	$5.1	$31.9	12.8%	3.0%	0.5%	$627.8
Nebraska	$2.5	$14.4	$86.4	16.8%	2.9%	0.5%	$610.2
Pennsylvania	$21.5	$77.3	$554.8	13.1%	3.6%	0.5%	$579.9
Texas	$54.8	$129.1	$1,144.7	9.0%	3.8%	0.4%	$520.3
North Carolina	$18.7	$49.8	$398.0	9.5%	3.6%	0.4%	$495.0
Colorado	$7.9	$31.8	$252.7	11.3%	2.8%	0.4%	$462.8

TABLE A2—NECESSARY CONTRIBUTIONS AND CONTRIBUTION INCREASES FOR FULL FUNDING IN 30 YEARS UNDER ALTERNATIVE ASSUMPTIONS

		Total Required Contribution				Required Increase Above Current Rates			
		ABO, 10yr Average U.S. GSP Growth		EAN, 10yr Average GSP Growth		ABO, 10yr Average U.S. GSP Growth		EAN, 10yr Average GSP Growth	
Contributions / Payroll	Weighted Average	40.0%		43.2%		23.7%		26.8%	
	Mean, StDev	38.5%	6.1%	41.0%	7.0%	21.8%	6.8%	23.7%	7.4%
	Min, Max	24.6%	56.1%	26.1%	59.3%	7.5%	42.5%	8.8%	46.1%
	Min State, Max State	NC	CO	NC	CO	IN	CO	IN	CO
Contributions / Tax Revenue	Weighted Average	22.3%		24.1%		13.2%		15.0%	
	Mean, StDev	20.9%	5.1%	22.2%	5.7%	11.8%	4.4%	12.9%	4.8%
	Min, Max	12.7%	35.2%	13.6%	37.6%	3.6%	24.7%	4.2%	26.3%
	Min State, Max State	IN	OR	ND	OR	IN	OR	IN	OR
Contributions / Total Own Revenue	Weighted Average	13.9%		15.0%		8.2%		9.4%	
	Mean, StDev	12.6%	2.9%	13.5%	3.3%	7.2%	2.6%	7.8%	2.9%
	Min, Max	7.3%	19.2%	7.5%	21.3%	2.2%	13.4%	2.6%	14.7%
	Min State, Max State	NE	NM	AK	IL	IN	OH	IN	OH
Contributions / GSP	Weighted Average	1.9%		2.1%		1.1%		1.3%	
	Mean, StDev	1.8%	0.4%	1.9%	0.5%	1.0%	0.4%	1.1%	0.4%
	Min, Max	1.1%	3.1%	1.2%	3.3%	0.3%	1.9%	0.4%	2.1%
	Min State, Max State	IN	NM	DE	NM	IN	OH	IN	OH
Contributions / Household	Weighted Average	$2,303		$2,486		$1,362		$1,545	
	Mean, StDev	$2,105	$637	$2,240	$677	$1,196	$482	$1,300	$521
	Min, Max	$1,165	$3,949	$1,268	$4,242	$329	$2,250	$385	$2,419
	Min State, Max State	IN	NY	IN	NY	IN	NY	IN	NY

TABLE A3—CONTRIBUTION INCREASES INCLUDING TIEBOUT EFFECT, NO POLICY CHANGES

		ABO, 10yr Average GSP Growth		ABO, 10yr Average GSP Growth - 1%		ABO, 10yr Average National GSP Growth		EAN, 10yr Average GSP Growth	
Δ[Contributions / Payroll]	Weighted Average	24.9%		27.4%		24.2%		27.6%	
	Mean, Standard Dev	21.6%	8.7%	23.6%	10.0%	21.8%	7.7%	24.5%	8.6%
	Min, Max	5.4%	43.7%	6.3%	53.1%	4.6%	47.1%	7.0%	49.0%
	Min State, Max State	IN	CO	IN	IL	IN	CO	IN	CO
Δ[Contributions / Tax Revenue]	Weighted Average	13.9%		15.3%		13.5%		15.4%	
	Mean, Standard Dev	11.8%	5.6%	12.9%	6.4%	11.9%	5.0%	13.3%	5.6%
	Min, Max	2.6%	27.8%	3.0%	30.1%	2.2%	29.1%	3.4%	30.3%
	Min State, Max State	IN	OR	IN	OH	IN	OR	IN	OR
Δ[Contributions / Own Revenue]	Weighted Average	8.7%		9.5%		8.4%		9.6%	
	Mean, Standard Dev	7.2%	3.3%	7.8%	3.9%	7.2%	2.9%	8.1%	3.4%
	Min, Max	1.6%	16.7%	1.8%	20.2%	1.3%	15.6%	2.0%	17.3%
	Min State, Max State	IN	OH	IN	IL	IN	OR	IN	OH
Δ[Contributions / GSP]	Weighted Average	1.2%		1.3%		1.2%		1.3%	
	Mean, Standard Dev	1.0%	0.5%	1.1%	0.6%	1.0%	0.4%	1.1%	0.5%
	Min, Max	0.2%	2.4%	0.3%	2.7%	0.2%	2.2%	0.3%	2.5%
	Min State, Max State	IN	OH	IN	OH	IN	OR	IN	OH
Δ[Contributions / Household]	Weighted Average	$1,435		$1,578		$1,394		$1,591	
	Mean, Standard Dev	$1,196	$584	$1,305	$666	$1,211	$564	$1,353	$609
	Min, Max	$237	$2,553	$274	$3,130	$201	$2,541	$307	$2,634
	Min State, Max State	IN	OH	IN	IL	IN	WY	IN	OH

TABLE A4—REQUIRED CONTRIBUTION INCREASES, 2% TIEBOUT EFFECT, NO POLICY CHANGE

	Gvt Contributions		Required Contribution Increase				
	Current ($B)	Required ($B)	% of Payroll	% of Tax Revenue	% of Own Revenue	% of GSP	per household
Ohio	$3.1	$14.4	41.3%	26.5%	16.7%	2.4%	$2,552.9
Oregon	$1.3	$4.8	40.7%	27.8%	14.9%	2.1%	$2,415.1
New York	$13.1	$31.1	27.4%	13.1%	9.1%	1.6%	$2,399.7
Illinois	$6.0	$17.6	39.6%	21.9%	15.1%	1.8%	$2,336.0
California	$19.5	$49.6	27.9%	18.8%	11.5%	1.6%	$2,122.4
New Jersey	$3.6	$10.6	25.9%	14.6%	10.6%	1.4%	$2,076.7
Wyoming	$0.2	$0.6	23.6%	10.2%	6.5%	1.2%	$2,074.1
Minnesota	$1.7	$5.9	30.7%	17.9%	11.7%	1.6%	$2,046.1
New Mexico	$0.9	$2.5	33.3%	23.3%	13.1%	2.1%	$2,011.0
Colorado	$0.9	$4.3	43.7%	19.5%	10.9%	1.4%	$1,785.3
Pennsylvania	$2.8	$10.5	35.9%	15.2%	10.0%	1.4%	$1,592.8
Wisconsin	$1.4	$4.8	27.7%	14.6%	9.5%	1.4%	$1,563.0
Michigan	$3.0	$8.7	33.9%	16.4%	10.0%	1.5%	$1,482.1
Washington	$2.5	$5.9	20.4%	13.2%	7.3%	1.0%	$1,345.7
Connecticut	$1.6	$3.4	20.3%	8.9%	6.9%	0.8%	$1,340.9
Kentucky	$1.1	$3.3	27.2%	15.7%	9.7%	1.4%	$1,300.0
Missouri	$1.8	$4.7	27.0%	15.6%	9.7%	1.2%	$1,267.1
Texas	$5.0	$16.9	21.8%	15.1%	9.2%	1.0%	$1,252.2
South Carolina	$1.5	$3.7	24.2%	18.2%	8.1%	1.3%	$1,220.5
Hawaii	$0.7	$1.3	16.1%	9.7%	6.5%	0.9%	$1,205.4
Kansas	$0.9	$2.2	18.7%	11.4%	6.9%	1.0%	$1,168.5
Delaware	$0.3	$0.7	18.7%	11.1%	5.8%	0.7%	$1,162.7
Mississippi	$1.1	$2.4	22.5%	15.0%	8.4%	1.4%	$1,161.6
Alaska	$0.3	$0.6	13.6%	5.4%	2.9%	0.7%	$1,160.1
Vermont	$0.2	$0.4	22.9%	9.5%	6.4%	1.1%	$1,145.9
Louisiana	$1.5	$3.3	20.4%	11.0%	6.9%	0.9%	$1,043.8
Massachusetts	$2.2	$4.8	18.7%	8.5%	5.5%	0.7%	$1,024.3
North Dakota	$0.2	$0.4	20.5%	7.6%	4.9%	0.8%	$1,006.2
Virginia	$4.2	$7.2	17.2%	10.4%	6.4%	0.7%	$993.6
New Hampshire	$0.4	$0.8	19.3%	10.3%	6.4%	0.8%	$949.9
Nevada	$1.2	$2.0	16.3%	8.8%	5.6%	0.7%	$835.5
Montana	$0.3	$0.6	18.4%	9.2%	5.5%	0.9%	$826.1
Nebraska	$0.4	$1.0	22.7%	8.0%	4.0%	0.7%	$825.2
Alabama	$1.9	$3.4	14.6%	11.5%	5.8%	0.9%	$819.5
Iowa	$0.9	$1.8	14.6%	8.0%	4.7%	0.7%	$811.6
Tennessee	$1.6	$3.6	19.7%	11.2%	5.5%	0.8%	$793.7
Oklahoma	$1.4	$2.5	17.5%	9.1%	5.4%	0.7%	$773.5
Florida	$5.5	$11.0	19.1%	8.4%	5.0%	0.7%	$766.3
North Carolina	$1.8	$4.5	14.7%	9.2%	5.5%	0.7%	$764.3
Georgia	$2.5	$5.4	19.0%	9.5%	5.7%	0.7%	$748.6
Maryland	$2.2	$3.9	13.9%	6.0%	4.4%	0.6%	$732.2
South Dakota	$0.2	$0.4	15.0%	9.0%	5.3%	0.6%	$729.7
Idaho	$0.5	$0.9	15.8%	9.8%	5.7%	0.8%	$707.1
Maine	$0.3	$0.7	16.8%	6.4%	4.4%	0.7%	$686.8
Rhode Island	$0.6	$0.9	11.3%	5.9%	3.9%	0.6%	$661.4
Arizona	$2.0	$3.4	10.4%	6.9%	4.2%	0.5%	$544.3
West Virginia	$0.7	$1.0	12.6%	5.7%	3.5%	0.6%	$514.1
Arkansas	$0.8	$1.3	13.3%	5.5%	3.6%	0.5%	$465.2
Utah	$0.9	$1.3	8.9%	4.7%	2.5%	0.3%	$363.2
Indiana	$2.2	$2.8	5.4%	2.6%	1.6%	0.2%	$237.4