Journal of Pension Economics and Finance (2024), 1–21
doi:10.1017/S1474747224000064

CAMBRIDGE UNIVERSITY PRESS

ARTICLE

The actuarial sources of the rise in unfunded liabilities in America's defined benefit plans in the 21st century

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(Received 16 February 2023; revised 16 February 2024; accepted 4 April 2024)

Abstract
Despite a decade-long bull market between the financial crisis and the COVID-19 recession, state defined benefit pension plans had accrued more than $1.37 trillion in unfunded liabilities. However, little work has investigated the actuarial sources of these unfunded liabilities. This paper uses original data hand collected from publicly available financial reports between 2000 and 2020 for 145 state-administered pension plans to determine the sources of unfunded liabilities. The largest unfunded liability contributor is investment experiences (when actual investment returns do not match assumed returns). The second and third largest contributors are changes to actuarial assumptions and expected changes (or interest accruing on existing unfunded liabilities). Benefit experience and legislative changes, demographic experience, and explicit funding shortfalls account for relatively little of the growth in unfunded liabilities. Moreover, the specific sources of unfunded liabilities are heterogeneous over time and across plans.

Keywords: public pensions; unfunded liabilities

JEL Codes: H75

1. Introduction

Between the financial crisis and COVID-19 recession, state defined benefit (DB) pension plans experienced a decade-long bull market that took public equity markets to historic heights.[1] Concurrently, nearly every state in the country made changes to their DB plans, usually with the objectives of reducing costs and improved risk management (Doherty *et al*., 2012; McGee, 2017; Brainard and Brown, 2018; Randazzo, Gilroy, and Christensen, 2018a; Randazzo, Gilroy, and Takash, 2018b). Yet, state DB pension plans had accrued more than $1.37 trillion worth of unfunded liabilities (UALs) at the end of 2020, more than any other point in American history (Randazzo and Moody, 2022).[2]

UALs, and the amortization payments to reduce them, eat scarce dollars in state and local budgets, leaving fewer resources available to expand or maintain the size of the workforce, raise salaries, and meet other spending priorities (Aldeman, 2016; Nation, 2018; Anzia, 2020; Kim *et al*., 2020; Aaron *et al*., 2022). State and local government employers paid an historic $150.3 billion in contributions to their DB plans in fiscal year 2020 to cover growing costs with the majority going to UAL

[1]State pension plans did not reap the full benefits of that bull market. As of 2020, pension plans, on average, invested 45.3 percent of their assets in equities (Randazzo and Moody, 2022).

[2]$1.37 trillion unfunded liability calculation based on Equable Institute's tabulation of actuarial valuations and other financial reports for state-administered retirement systems using market valuation of assets or fiduciary net position (Randazzo and Moody, 2022).

https://doi.org/10.1017/S1474747224000064 Published online by Cambridge University Press

amortization payments (Randazzo and Moody, 2022). Investment returns for state pension funds in 2021 reached historic heights, but were followed by substantial investment losses in the 2022 fiscal year ending June (Hawkins, 2022). Given these trends, there will still be tens of billions of UAL amortization payments required in the coming years, and policymakers are likely to look for new ways to mitigate this funding challenge.

Matching those mitigation approaches with policies that will appropriately address the proximate causes of the surge in funding deficits is a puzzle that has become important to solve. The nature of the specific causes of pension UAL has been notionally discussed in previous academic literature analyzing the general political, institutional, and economic reasons for the rise in UALs over the years (see Randazzo, 2017, for a review). There has been considerable work on the *effects* that unfunded pension liabilities have had on education (Koedel, 2019; Melnicoe *et al.*, 2019; Moody and Randazzo, 2020), worker benefits (Aldeman, 2016; Aubry and Wandrei, 2020; Moody *et al.*, 2022), and municipal finances (Anzia and Moe, 2017), but there is comparatively little analysis evaluating the concrete financial reasons for the underfunding (Munnell *et al.*, 2015) or providing a comprehensive picture of the evolution of UALs since 2001 – when statewide retirement systems were collectively about $7.4 billion overfunded – up through the most recent complete data on record. Answering the question of what precisely has caused today's UAL for state DB plans can help policymakers and pension boards as they consider various policies necessary to respond to growing costs and potential effects of the pandemic.

The purpose of this paper is to investigate what went wrong over the last 20 years that led to such large unfunded pension liabilities and to offer lessons for the future management of these retirement systems that may help prevent the accumulation of future UAL.[3] To do this, we hand collected actuarial data on gains and losses to UAL from publicly available financial reports from the end of fiscal year 2000 through fiscal year 2020 for 145 state-administered pension plans covering over 96 percent of all state-administered pension fund assets nationwide. Next, we categorized these data into eight categories and 27 subcategories in a novel taxonomy to reflect a census of reported changes to each respective retirement plan's assets and liabilities. We then broke out the total gains and losses for each category and subcategory to show their growth since fiscal year 2000, illustrating how each respective category and subcategory has contributed to the full UAL for all plans.

Our results show that the most substantial growth in UAL is attributable to investment experience (or investment underperformance relative to plan assumptions), accounting for 40.7 percent of the increase. Additional major drivers of the UAL growth since 2000 include assumption changes (28.4 percent) and interest on the debt (23.9 percent). Notably, the relative importance of these major factors changed over time: assumption changes (typically assumed rates of return) have become more frequent and contributed more to UAL growth between 2013 and 2019 than investment experience.

Demographic experience accounted for a small reduction in UAL (0.5 percent), but this is because two subcategories largely cancel each other out: improvements in UAL levels due to turnover and retirement experience not matching up with assumptions (7.6 percent) balance out sizable reductions in UAL attributable to salaries failing to grow at expected rates (8.4 percent). But, as with almost any 50-state analysis, there are significant levels of variance among the states relative to these national averages. The primary drivers vary over time and across plans.

This paper makes three key contributions to the scholarly understanding of what accounts for the rise in UAL as documented in the current literature. First, while others argue generally that UAL rose because of different political, economic, and institutional sources, we offer a formal empirical evaluation of how much of the rise in UAL is attributable to each of the commonly identified sources.

[3]One solution that we do not discuss that would prevent future accumulation of unfunded liabilities is to reform public employee retirement plan to plan options that do not accrue unfunded liabilities, such as defined contribution and cash balance plans. While policymakers may consider reform, public employees tend to value pension plans more than alternative retirement plans (Fuchsman *et al.*, 2023). Furthermore, stakeholders and politicians can win political points and make current workers happy by continuing DB plans or expanding benefits while these paying for these benefits can be deferred to future generations (Anzia and Moe, 2017; Randazzo, 2017).

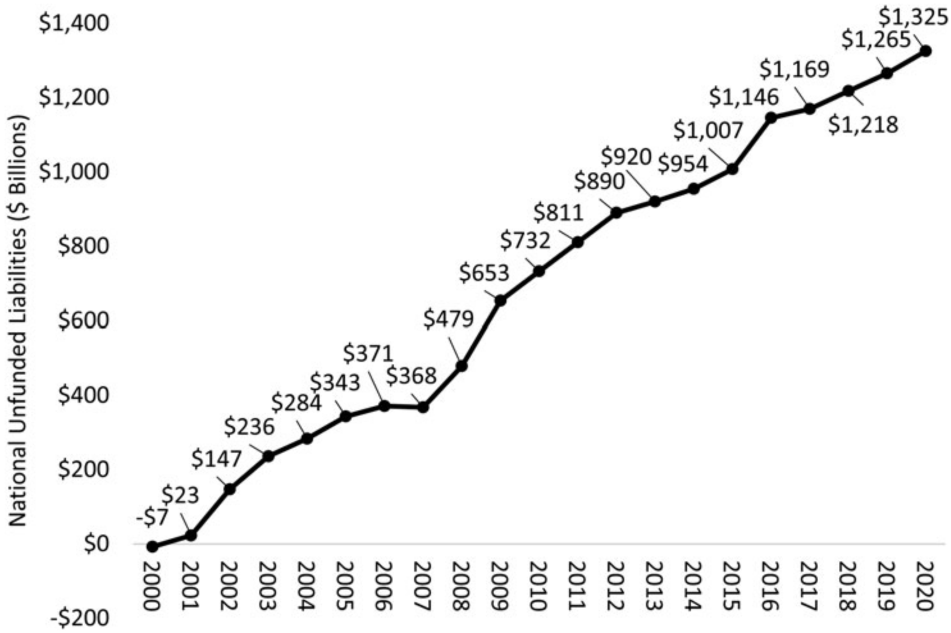

Figure 1. Accrual of unfunded liabilities from 2001 to 2020.
Notes: Authors' tabulation of actuarial valuations and other financial reports for state-administered retirement systems using actuarial valuation of assets.

Second, we illustrate the heterogeneity in how UAL grew across plans and over time. Third, we offer evidence that challenges and supports some common claims about what has caused UAL to accumulate, such as benefit enhancements, failing to pay contributions, and discounting at overly optimistic assumptions about investment returns.

2. Background

At the turn of the 20th century, DB plans were $7.4 billion overfunded.[4] Over the next 20 years, DB plans accrued over one trillion dollars of UALs. Among the 145 plans in our dataset, UAL had reached $1.33 trillion by 2020.[5] Figure 1 shows the accrual of UALs from 2001 to 2020. The largest year-to-year increase was between 2008 and 2009 as the losses from the financial crisis reduced most plans' funded status, but UAL continued to increase in the years that followed.

Our aim is to achieve a better understanding of the actuarial sources that have led to historically high UAL in 2020. This section discusses what the consequences of UALs have been to date and provides an overview of the speculation for which sources of UAL are likely to be the most important contributors. We then briefly describe a conceptual model of UAL that guides our taxonomy and describe other efforts to identify the actuarial sources of UAL.

[4]Based on our tabulation of actuarial valuations and other financial reports for state-administered retirement systems using actuarial valuation of assets for the sample of plans described below.

[5]The exact UAL total depends on how many of the 5,340 state and municipal plans are included (Mayo and Caskey, 2021). We note that Equable's State of Pensions report, reported $1.37 trillion in unfunded liabilities at the end of fiscal 2020. However, not all of the plans included in Equable's report provide sufficient documentation or data to record their actuarial gains and losses to the detail we require. As such, our analyses were limited to the plans mentioned, which indicate a total UAL of $1.33 trillion in 2020. This indicates that the plans included in our dataset account for over 89% of the national DB assets covered in Equable's report.

2.1 Consequences and speculative sources of unfunded liabilities

Rising pension costs, mostly attributable to paying down UAL, have had a notable effect on the budgets of states, local governments, and even school districts. For schools, the share of per pupil expenditures going to fund teacher retirement benefits has nearly tripled since 2004 and now accounts for over 11 percent of per pupil expenditures (Costrell, 2022), and have traded off with raises for teachers and other education expenditures (Aldeman, 2016; McGee, 2016; Melnicoe *et al.*, 2019; Moody and Randazzo, 2020). After the Great Recession, teacher pension expenditures were associated with decreased salary expenditures, operating through a reduction in the teacher workforce (Kim *et al.*, 2020). While rising pension contributions are not associated with increases in revenue, they correspond with downsizing public employee workforces (Anzia, 2020). In California, rising pension costs have come at the expense of 'social, welfare and educational services', 'libraries, recreation, and community services', and 'social services to the elderly, blind, disabled and other children and adults, licensing and regulating foster homes, group homes, residential care facilities, day care facilities, and preschools' (Nation, 2018, pp. xi and 14).

Because of the adverse consequences of UAL accumulation, there is no shortage of conjecture for why the UAL has risen. One common argument made by conservatives is that governments provide overly generous benefits and gave out benefit enhancements without paying for them. An argument made by labor union leaders is that governments have not paid the required contributions. Economists, meanwhile, have blamed the rising UAL on discounting future cash flows at an implausibly high assumed rate of return (Novy-Marx and Rauh, 2011; Biggs, 2012; Novy-Marx, 2015). Despite each of these explanations and state-specific analyses, there is a lack of empirical evidence evaluating and comparing each of these claims across all state pension systems, and there have been comparatively few attempts to attach a dollar value to each explanation to see how much of the total UAL they account for.

Political and institutional factors may help explain what allowed the rise in UALs, but much of the evidence on any of these individual political and institutional factors is mixed. Term limits for state legislators, who would theoretically have less incentive to push costs down the road to future policymakers, do not consistently affect pension funding levels positively or negatively (Thom, 2013; Elder and Wagner, 2015; Thom and Randazzo, 2015). The same inconsistent findings are present for political party control of state governments and collective bargaining (Coggburn and Kearney, 2010; Thom, 2013; Thom and Randazzo, 2015). Pension board composition also has mixed effects on UAL accrual (Yang and Mitchell, 2005; Bradley *et al.*, 2016; Smith and Dove, 2016). However, institutional and political explanations may only describe what enabled UALs to rise. While reform-oriented discussions can benefit from helping stakeholders understand how political incentives shape decision-making, more immediate improvements can be made by understanding the proximate causes of the rises in UAL.

Perhaps the most universally understood reason for the rise in the UAL since 2000 is the importance of the 'assumed rate of return'.[6] Coming into the 21st century, most pension plans assumed that their investments would earn an average of 8.07 percent returns each year.[7] However, as financial markets evolved over the past 20 years, plans have been slow to adjust those investment assumptions: the average assumed return remained at almost 8 percent (7.94 percent) prior to the financial crisis and only dropped below 7 percent to 6.93 percent in 2021 after the onset of the pandemic (Randazzo and

[6]Less well known generally, although well documented in financial literature, is the effect of assumed rates of return on discount rates, and the subsequent effect on unfunded liabilities. Economists argue that plans should calculate the present value of assets using a discount rate that reflects the investment portfolio's risk and not just its expected return (Novy-Marx, 2015). To this end, several articles document that discounting at rates consistently higher than actual investment returns has contributed to UAL accrual (e.g., Biggs, 2012; Costrell, 2018; Smith and Dove, 2016).

[7]We note that plans' assumed investment returns technically refer to their long-term expectations for what their investments will earn. However, while plans expect variation around their plan assumptions, each year that a plan underperforms its investment assumption results in unfunded liabilities that must be resolved at some point, either through future investment gains above the plan assumption, increased contributions, or otherwise.

Moody, 2022). A common practice has been for pension trustees to use aggressive investment strategies, which can yield high returns but with considerable risk that investments will underperform.

Another economic explanation for the increase in UAL is funding policy. Amortizing existing pension debt over long periods, coupled with large payroll growth assumptions, can result in contribution rates that are less than the interest accrual on existing UAL (Stein *et al.*, 2014; Costrell, 2018). Recent simulation work shows that choosing certain funding policies that aim to reduce costs over an extended period of time run the risk of allowing UALs to explode further (Boyd and Yin, 2018; Costrell and McGee, 2020). Regardless of whether a funding policy is appropriately designed to generate adequate contribution rates, state governments, such as Illinois and New Jersey, have notoriously not always paid the full required contribution rates determined in the first place (Marcus, 2015; Anzia and Moe, 2017; Bui *et al.*, 2022; *State of Illinois Retirement Systems: Funding History and Reform Proposals*, 2008).

2.2 The 'gains and losses' framework for unfunded liabilities

Despite the many potential explanations for why the UAL has increased, comparatively little work has attempted to tie all of them together into a complete narrative. Moreover, none of the existing work describes how dynamic the sources of UALs have been across a majority of public plans.

Munnell *et al.* (2015) were the first to track the financial sources of UAL in any coherent way with a simplified presentation of actuarial gain/loss data over time. They initially applied this approach in Georgia and New Jersey, before later applying it in Connecticut (Aubry and Munnell, 2015; Munnell *et al.*, 2015). This approach was also utilized in separate analyses of retirement plans in South Carolina (Randazzo *et al.*, 2016); Austin, Texas (Takash *et al.*, 2018); and Colorado (Randazzo, Gilroy, and Christensen, 2018a). However, to date, this approach has been limited to these specific states, plans, or cases despite offering a robust method to garner a better understanding of the changes to a plan's UALs in any given year. As such, we opt to utilize this approach to examine a census of all state-level plans with more than $1 billion in actuarially accrued liabilities and refine the framework for the categorization of gain/loss data.

Costrell (2018) offers a criticism of this methodological approach of tabulating actuarial gain/loss data on the grounds that it does not fully account for the future amortization costs. The crux of his argument is that the impact of the assumed investment return rate is undervalued in the methodological approach of Munnell *et al.* (2015) and similar work because it impacts amortization costs in addition to its impact on investment experience. Pairing a level percent of payroll amortization formula with a high investment return assumption results in funding shortfalls for long amortization periods and a high payroll growth assumption. Combining these assumptions and amortization parameters results in amortization payments less than currently accruing interest, which raises the UAL despite a contemporaneous amortization payment. Costrell argues that this type of UAL increase is a result of the investment return assumption.[8] However, this criticism is about how the investment return assumption affects the costs of UAL, rather than their value.[9]

The purpose of this paper is to show what factors caused UALs to rise, with the aim to inform future discussions about how to prevent UAL from continuing to increase in the future. In other words, this paper is about the value of UALs and not their costs. The policy importance of gain/loss data is how they uncover the actuarial causes of UAL. Identifying the root causes behind the UAL can aid in identifying shortcomings in funding policy, contribution behavior, or other factors that can be adjusted by policymakers, pension boards, or other stakeholders. The political process

[8]Costrell (2018) correctly argues that how the costs associated with an increase in unfunded liabilities each year are amortized over subsequent years matters and that the amortization of those costs might show up in other categories. However, the methodological approach to assigning actuarial gain/loss categories that Costrell proposes is appropriate to understanding the cost of unfunded liabilities over time, rather than the composition of UAL.

[9]Costrell's (2018) criticism is more related to the common actuarial practices for assigning factors that increase or decrease unfunded liabilities.

https://doi.org/10.1017/S1474747224000064 Published online by Cambridge University Press

determining how parameters underlying a plan's amortization were chosen is less relevant to responsible plan management than understanding how amortization has increased UAL.

3. Data

Our analyses utilize data published by DB plans related to actuarial gains and losses to UALs experienced each year on an actuarial valuation of assets basis. We combed through publicly available financial reports, such as actuarial valuations and annual comprehensive financial reports (ACFRs), by hand to collect actuarial gain/loss data. The compiled dataset includes gain/loss data going back to the end of fiscal year 2000 and up through FYE 2020.

We collected gain/loss data from each plan individually in four steps. First, we extracted the data from plan documents into our own spreadsheets. We did not change any terminology from the plan reports in this stage to preserve the integrity of the underlying gain/loss data. Second, we reviewed all plan reports to ensure they were transcribed correctly and that all values in our spreadsheets matched those reported in plan valuation reports or ACFRs. Third, we confirmed that all gain/loss data were consistent with actual reported changes to UALs elsewhere in the actuarial reports.[10] Fourth, we standardized the data to ensure consistency in reporting, both in dollar totals reported and in directionality of gains and losses, such that gains in UALs reflect an increase in a plan (or the total) UAL, while losses reflect reductions in UAL.[11]

Data collection encompassed all pension plans, guaranteed return (or cash balance) plans, and hybrid retirement plans that included a DB element at the state level in the United States. The resulting dataset covers the overwhelming majority of state UALs and only leaves out small pension plans with less than $1 billion in actuarially accrued liabilities. We excluded 15 plans that met the liability threshold because they either did not provide complete data or only provide gain/loss data showing changes to contribution rates (where we could not infer estimated dollar changes).[12,13]

Finally, on occasion actuarial valuation reports provided slightly different UAL figures in their actuarial gain/loss tables as opposed to other tables that report aggregate asset, liability, and funding shortfall data. In some cases, data in gain/loss tables were rounded whereas UAL data elsewhere were provided in actuals. We used the actuarially valued UAL data from the gain/loss tables to ensure consistency with rounding across data in an individual report. As a result, there are minor differences in the 2020 UAL from these gain/loss data versus the measurements that have been reported elsewhere in the actuarial valuation reports or ACFRs.

[10]There were few instances in which the summed gain/loss data match the total unfunded liabilities elsewhere in the paper. The cause of the inconsistency was generally due to rounding errors in the actuarial reports. To calculate the unfunded liability total, we used the gain/loss data.

[11]Two common discrepancies across reports were how actuarial reports denominated totals in the gain/loss tables (i.e., actual, thousands, millions, billions) and whether a figure reflected a gain or loss to unfunded liabilities (essentially whether gains reflected an increase or decrease in unfunded liabilities). After initial data collection, we standardized data to be nominal actual dollars and forced positive values to reflect an increase in unfunded liabilities. Individual plan data are available upon request.

[12]One of these plans is a portion of California Public Employees Retirement Fund A. PERF A, as a whole, is a large agent multiple-employer plan that represents three-quarters of CalPERS's unfunded liabilities. Gain/loss data are provided for PERF A 'State Agency' unfunded liabilities (53% of PERF A), but not for 'Local Public Agency' unfunded liabilities (47% of PERF A). As a result, our data only capture about half of the total unfunded liabilities for PERF A. Practically speaking, this means we were unable to record gain/loss data that would account for $54.4 billion from FYE 2019's measured unfunded liabilities (or 4.3% of the total). The other 14 plans we had to remove from our dataset account for 1.6% of the total 2019 unfunded liability figure.

[13]One challenge in compiling these data was to accurately reflect the 'expected changes in unfunded liabilities', which can be thought of as interest on the outstanding UAL. In some cases, plans disclose this directly in their gain/loss tables in a manner such that we could classify it easily. However, in many other cases we were forced to calculate these expected changes based on documented differences in UAL from year-to-year or on otherwise undocumented gains or losses to the UAL in any given year. In most cases this process was straightforward and allowed for an easy calculation to account for upwards of 99.9% of the changes in UAL; however, there were some plans where this process was not possible, which contributed to our decision to omit these plans from our analyses.

Once we removed plans with incomplete or missing gain/loss data, the 2020 UAL figure we were seeking to understand the source of became $1.33 trillion across 145 plans rather than the full $1.37 trillion figure. The resulting dataset covers 96.7 percent of the $1.37 total reported UAL in 2020 documented in Equable's report and covers more than 11.8 million active members and over 9.2 million retirees.[14] The adjustment of $45 billion is a substantial dollar amount in practical terms, but we do not believe there to be any systematic biases resulting from this discrepancy because it is such a small number in relative terms (and there are no major conclusions in this paper for which $45 billion would have changed the outcome or assessment).

3.1 Sources of unfunded liabilities taxonomy

The Actuarial Standards Board, which provides guidance to actuaries on a variety of topics including reporting and disclosures, does not have a requirement to disclose gain/loss data, nor do they suggest a process for how to provide these data when voluntarily disclosed. This lack of guidance means that there is considerable heterogeneity in the way gain/loss data are presented in actuarial reports, both across plans and over-time within each plan. Fortunately, most reports use meaningfully similar terms when disclosing their gain/loss data, but ambiguities may persist. It is important to recognize that the lack of rules and guidance allow for the possibility that policymakers and/or trustees could shift actuarial sources so that plans appear to be better managed. This can come in many forms. For instance, a board of trustees could make the choice to maintain a high discount rate (and assumed rate of return) to minimize UAL for political reasons. However, as there is no guidance regarding any 'correct' rate to discount liabilities, we are subject to the limitations of the data as they are reported. The plan that held the high discount rate only to lower it later would report the shift in its UAL as a result of changes to plan assumptions. These data capture the actuarial causes of UAL, regardless of whether they are issues stemming from funding policies or active choices that have been made by plan administrators and pension boards.

To address the challenges that result from a lack of standardized reporting, and to provide a means to analyze these raw gain/loss data in the aggregate, we aimed to develop a simple taxonomy of the sources of UAL. We considered several potential versions of the taxonomy. For example, should all 'experience' be grouped together or separated? Are UAL increases due to failing to pay actuarially required contributions different than when interest on UALs grows by more than plans contribute? Should we start with two main groupings of sources that affected assets and sources that affected liabilities?

While there are merits to each possible approach, we developed a simple, intuitive, taxonomy with two levels. We began by going through the hundreds of data labels in the actuarial reports and identified 30 subcategories that we used to bundle individual gains and losses. The data labels in these subcategories can vary, but by establishing a large enough set of subcategories we were able to avoid excessively subjective decisions about when to bundle two potential groups together. For example, even though 'COLA experience' and 'benefit experience' are highly similar (they are both functions of the pension benefit paid), we opted to keep them separate to maintain the option of analyzing any distinct effect of each on the accumulation of UAL.[15]

There are several subcategories for 'other' or 'general (unspecified)' changes. The 'other' subcategories generally refer to situations where we could easily consider gain/loss data as part of a separate subcategory, but the subcategory was not included in many other actuarial reports. For example, lump sum transfers in or out of the DB plan, pension obligation bond revenues, and lottery revenues were included in the subcategory of 'other investment related'. We note, however, that these 'other' groups do not account for a substantial gain/loss in UAL. Meanwhile, the 'general (unspecified)' category

[14]In contrast, Social Security provided benefits to roughly 69.8 million retirees in 2020, while covering 251.0 million people through their primary benefit program (not including SSDI) (Social Security Administration, n.d.).

[15]Our dataset is available here.

Table 1. Defined benefit gain/loss categorization

Main category/factors	Subcategories/subfactors		
Investment experience This is any asset-related experience, such as investment returns performing better or worse than assumed	Investment experience	Other investment related	General (unspecified) asset gain/loss
Demographic experience This is any accrued liability experience relative to related assumptions	Payroll or salary experience	Turnover or retirement experience	
	Disability experience	Mortality experience	
Assumption changes This is any changes to actuarial assumptions that increase or decrease accrued liabilities	Investment assumption change	Mortality assumption change	Payroll/salary assumption change
	General (unspecified) assumption change	Other (specified) assumption change	Other actuarial method change
Benefit experience and legislative changes This is any benefit experience that changes accrued liabilities or legislative changes that adjust benefit values	Benefit formula change	Benefit experience	General (unspecified) benefit design change
	COLA change	COLA experience	Service purchases
Contribution experience This is explicit funding experience	Contribution deficiency/surplus	Changes to funding policy	
Interest on the debt This is implicit funding experience	Expected change (or interest on the debt)		
Other and unspecified This is any unclassified change to accrued liabilities[a]	General (unspecified) experience gain/loss	Unspecified amendments	Data corrections
	Actuarial firm change	Undeclared or other	General (unspecified) actuarial liability gain/loss
20th Century legacy and starting status This is any unfunded liability that was reported by a plan as of FYE 2000 (thus is unmeasured), or the starting level of overfunding or underfunding from a plan's point of measurement[b]			

Notes: See Appendix X for complete details about the definitions of these categories and subcategories.
[a]A number of plans do not break out complete demographic categories of changes to accrued liabilities, and simply report a cumulative 'actuarial gain/loss' change or have an 'experience gain/loss'. These can reasonably be understood to be demographic experience and/or benefit experience, but we do not classify them as such because the plans did not report the data breakout publicly.
[b]The sources of 20th century legacy unfunded liabilities are typically related to years when states were not explicitly prefunding their defined benefit plans, but they can also be related to unfunded benefit enhancements, investment experience, and other categories. For a few plans we did not have data back to FYE 2000, so we measure changes to unfunded liabilities from their oldest reported data and mark this as such on their specific defined benefit plan chart.

arose because several states do not break out gain/loss data by any subcategory, making it impossible to accurately classify their data.[16]

With these subcategories in mind, we developed eight primary categories that group the gains and losses into largely intuitive segments. Table 1 details the taxonomy.

Investment experience refers to any asset-related experience. The self-referential subcategory is asset experience when actual investment returns do not match assumed investment returns. The 'other' subcategory included items such as lump sum transfers in or out of the DB plan, pension obligation bond revenues, and lottery revenues not counted in investment return experience.

Demographic experience refers to gains/losses where liability assumptions did not match experience (i.e., payroll experience deviated from assumed payroll). The assumption changes category includes changes to actuarial assumptions that affect accrued liabilities. Benefit experience and legislative changes cover any situation in which payments to members deviating from expected payments or when legislatures adjusted benefits. Contribution experience refers to explicit funding experience such as overpaying/underpaying the actuarially required contribution.

[16]Raw data files for each plan are available upon request.

Expected change (interest on the debt) refers to implicit funding experience, or – more technically – the difference between normal cost for benefits accrued during the measurement year (increasing actuarial accrued liabilities), plus interest on existing UAL, minus contributions in the measurement year. The other and unspecified category includes subcategories and items from the actuarial gain/loss tables that would not conform to other main categories.

Starting status and undocumented changes include plan UALs reported as of FYE 2000, the starting level of UAL, and all other liabilities that are unaccounted for. Undocumented changes occur when the gain/loss data were not provided and takes the value of plan's reported UAL change for that year.

Many of these categories and subcategories interact with one another, especially when experience and assumption changes are included. For example, actuaries conduct experience studies on a regular basis to evaluate how well their assumptions are performing and make changes to the assumptions when necessary. Experience would not account for any gain/loss in UAL in the years where assumption changes occur. From a timing perspective, experience-specific categories are a measurement of what has happened during the prior year relative to the assumptions in place during the prior year. Changes to actuarial assumptions like the discount rate or mortality tables are measured based on the value of accrued liabilities at the end of actual experience.

Finally, what is less clear is how actuaries handle multiple changes to actuarial assumptions and methods that happen at the same time. Because there are no notes in the valuation reports about this, nor any clear guidance in the Actuarial Standards of Practice, there is the possibility that the way this is handled varies from plan-to-plan or even by actuarial firm. Fortunately, such distinctions are only meaningful in a few cases when measuring subfactors for a specific plan in a specific year. As a result, the effects of these rare composite changes should not be large enough to meaningfully change our analyses.

4. Results

Using the taxonomy of sources of UALs, this section sums UAL totals to describe their actuarial sources. First, we describe the cumulative sources of UAL from FYE 2000 to FYE 2020. Next, we consider how the composition of cumulative UAL changed over the 21-year period before seeing how the sources of UAL changed each year. Finally, we show how heterogeneous the increase in UAL has been across plans.

4.1 Cumulative sources of 2020 unfunded liabilities

We begin with the cumulative sources of UALs up through FYE 2020 for the 145 state retirement plans for which data are available. These results are available in Table 2, where we present the eight primary categories and 30 subcategories from the taxonomy, described previously and outlined in Table 1. Note that to arrive at these totals, we aggregate UAL over time and across plans.

We find that investment (asset) experience was the largest contributor to UALs nationally over the past two decades. Of the $1.33 trillion national UAL total that we account for, $539.27 billion (40.69 percent) is attributable to the investment experience primary category. Looking into this category further we see that the subcategory for underperforming investments relative to plan assumptions accounts for $464.05 billion (35.02 percent of total UAL and 86.20 percent of the investment experience category).[17] Other investment-related sources (lump sum payments, pension obligation bonds, etc.) accounted for a net UAL loss (i.e., reduction of UALs) of 0.03 percent of the total UAL, while the general (unspecified) asset gain/loss subcategory accounted for $75.66 billion or 5.71 percent of the total.

The second largest driver of national UALs was assumption changes, which accounted for $376.70 billion (28.42 percent of the total). Unfortunately, a general lack of specificity in the actuarial data

[17]Across all years of data, the average assumed rate of return across plans was 7.59% while the average 1-year return was 6.72% and the average 10-year return was 7.63%. Yearly 1-year and 10-year returns are available in Appendix A.

Table 2. Subcategory sources of change in UAL from 2000 to 2020

Category		Subcategory			
Investment experience	$539.27 (40.69%)	Investment experience	$464.05 (35.02%)	Other investment related	−$0.45 (−0.03%)
		General (unspecified) asset gain/loss	$75.66 (5.71%)		
Demographic experience	−$6.20 (−0.49%)	Payroll or salary experience	−$110.82 (−8.36%)	Turnover or retirement experience	$100.87 (7.61%)
		Disability experience	$0.21 (0.02%)	Mortality experience	$3.54 (0.27%)
Assumption changes	$376.70 (28.42%)	Investment assumption change	$37.48 (2.83%)	Mortality assumption change	$1.72 (0.13%)
		Payroll/salary assumption change	−$0.46 (−0.03%)	General (unspecified) assumption change	$349.21 (26.35%)
		Other (specified) assumption change	$2.04 (0.15%)	Other actuarial method change	−$13.30 (−1.00%)
Benefit experience and legislative changes	−$47.93 (−3.62%)	Benefit formula change	$7.85 (0.59%)	Benefit experience	−$0.08 (−0.01%)
		COLA change	−$16.73 (−1.26%)	COLA experience	$2.08 (0.16%)
		Service purchases	$1.80 (0.14%)	General (unspecified) benefit design change	−$42.86 (−3.23%)
Contribution experience	$20.65 (1.56%)	Contribution rate deficiency/excess	$18.10 (1.37%)	Funding policy change	$2.54 (0.19%)
Expected change (or interest on the debt)	$317.12 (23.93%)				
Other and unspecified	$74.58 (5.63%)	General (unspecified) actuarial liability gain/loss	$40.77 (3.08%)	General (unspecified) experience gain/loss	$18.78 (1.42%)
		Actuarial firm change	−$0.10 (−0.01%)	Data corrections	−$6.90 (−0.52%)
		Unspecified amendments	$3.42 (0.26%)	Undeclared or other	$18.63 (1.41%)
Starting status and undocumented changes	$51.51 (3.89%)	20th Century legacy	−$15.94 (−1.20%)	Starting UAL	$16.22 (1.22%)
		Undocumented changes	$51.22 (3.86%)		

Notes: Authors' tabulation of actuarial valuations and other financial reports for state-administered retirement systems using actuarial valuation of assets. All totals reflect billions of dollars.

makes it difficult to account for which assumption changes led to this rise. Most pension plans report gain/loss data for 'assumption changes' generally. As a result, among the subcategories in our dataset, general (unspecified) assumption changes account for $349.21 billion (93 percent of cumulative UALs attributable to assumption changes).[18] When pension plans did occasionally provide details on their assumption changes, most of the reported changes were to the investment return assumption, which accounted for $37.48 billion in the growth of UALs. (Changing the investment return assumption typically changes the discount rate used to value accrued liabilities for most public pension funds; all else equal, this usually means an increase in UALs because asset valuations do not change with the change

[18]Future research could review each instance where a pension plan changed its discount rate or mortality table or some other assumption, and approximate how that might have changed the value of accrued liabilities, which would estimate the gain/loss from assumption changes for specific categories.

to measured benefit values.) Mortality assumption changes are responsible for $1.72 billion of national UALs, and payroll/salary assumption changes lowered national UAL by $460 million. The other (specified) assumption changes subcategory, which includes specific, but heterogeneous, changes to the plan's assumptions like an 'expiration of last year of short-term salary increase assumption', 'changes in actuarial assumptions on buyout utilization', and a 'change in valuation interest rate', accounted for $2.04 billion of UAL growth. Other actuarial method changes such as when the actuaries adopt a different asset valuation method or just general revisions of their actuarial methods accounted for a reduction of UAL by $13.30 billion.

The third largest UAL contributor was expected change (interest on the debt). Specifically, UAL increased $317.12 billion, or 23.93 percent of the total UAL, because of funding policies that resulted in contribution rates being less than the interest accrual on existing liabilities. In effect, this allowed states to pay less in certain years than if funding policies adequately ensured there would be no expected increase in the UAL. Formally, this is different than times when states explicitly chose not to pay all the required contribution (which is classified as contribution experience and described below).

The five remaining primary categories accounted for no more than 6 percent of total UAL. Even still, there are noteworthy results. Demographic experience accounted for a small net reduction in UAL of 0.47 percent, but not because experience matched assumptions. Turnover or retirement experience (workers remaining in their jobs as expected) accounted for a $100.87 billion increase, but this was balanced out because payroll or salary experience (payroll failing to grow as expected) accounted for a $110.82 billion reduction in UAL. Disability and mortality experience only accounted for a small increase in UAL.

Benefit experience and legislative changes have accounted for a cumulative reduction of UALs by $47.93 billion. Concerns that legislatures gave out too many benefit enhancements may not be founded as benefit formula changes only accounted for $7.85 billion of the UAL since 2000. There were few benefit enhancements during the years that our data covered and many of those enhancements came prior to the Great Recession.[19] COLA changes reduced UAL by $16.73 billion. However, the largest subcategory of benefit experience and legislative changes was the general (unspecified) benefit design change, which accounted for a $42.86 billion UAL reduction.

Explicit contribution experience also accounted for very little of the rise in UALs, totaling only $20.65 billion. Most of this rise was due to the subcategory of contribution rate deficiency where states/plans chose not to make their actuarially required contributions. As a point of comparison, growth in UAL due to *explicit* contribution experience was 6.5 percent of the *implicit* contribution experience that comes in the form of expected changes (interest on the debt).

The aggregate sources of UALs center around the investment experience and plan funding policies. As investment underperformance was the largest driver of the current UAL, plans could benefit from adjusting their investment return assumptions lower and discounting at this lower rate if they wish to reduce their exposure. Second, as expected changes in UAL (interest on the existing debt) was also among the most prominent drivers of their debt, plans would also benefit from pursuing funding policies that help ensure contributions are sufficient to prevent negative amortization through interest on their debt.

4.2 Cumulative sources of unfunded liabilities over time

While illuminating in the aggregate, the results in Table 2 mask how dynamic the sources of UALs have been over the last 21 years. To provide a better picture of how these sources have changed over time, we present the accrual of each primary UAL category in Figure 2 in nominal billions of

[19]Note that benefit enhancements do not guarantee increases in UAL. Many benefit enhancements pass because plans were overfunded or members paid for enhancements.

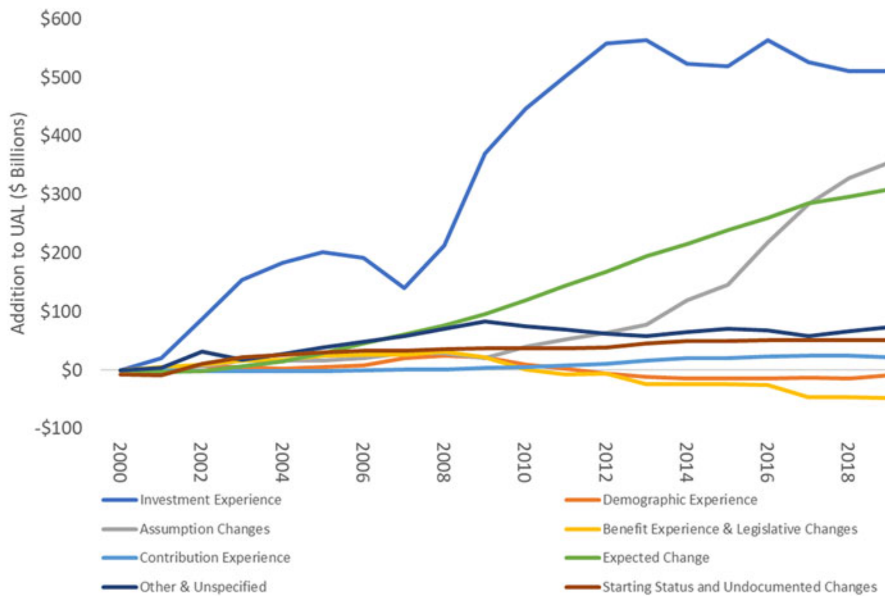

Figure 2. Sources of aggregate unfunded liabilities from 2000 to 2020.
Notes: Authors' tabulation of actuarial valuations and other financial reports for state-administered retirement systems using actuarial valuation of assets.

dollars from 2000 to 2020 for each plan in our gain/loss dataset.[20,21] Figure 3 offers these same data but adjusts them to indicate the normalized percentage share of total UAL accrual attributable to each primary category from 2000 to 2020.[22]

Investment experience has been a key contributor to the rise in UALs since 2001, as shown in the aggregate analyses in the prior section. This analysis reveals the share of UAL attributable to investment experience changed over time. The share rose between 2000 and 2006 before falling in 2007 when investment experience was 38.25 percent of aggregate UAL. It rose again until reaching a maximum of $564.09 billion in 2013, accounting for 61.31 percent of aggregate UAL. Despite reaching a maximum in terms of dollars, the percent of UAL due to investment experience has been decreasing since 2011. UALs declined because of investment experience in 2014 and 2015 but have risen since to reach $539.27 billion in 2020, accounting for 40.69 percent of the total.

Demographic experience has been a cumulative source of reductions to UALs since 2012. In 2008, demographic experience accounted for 5.66 percent, which was nearly entirely attributable to turnover experience. By contrast, UAL reductions attributable to payroll experience have exceeded gains attributable to turnover experience since 2011.[23]

The role of assumption changes in UAL accrual has been dynamic. This category accounted for less than 10 percent of UAL prior to 2013 but have accounted for between 24 and 29 percent since 2017. The sharp rise in UAL attributable to assumption changes began 2013. The largest gain was between

[20]While it would be possible to adjust figures for inflation, we felt it was a more appropriate approach to maintain all figures in nominal dollars for each given fiscal year, as plans assume different rates for inflation in their actuarial analyses and funding policies. As such, all figures reflect nominal totals as reported in plan valuation reports or annual comprehensive financial reports.

[21]Similar graphs displaying subcategories for Demographic Experience and Benefit Experience and Legislative Changes are available in Appendix A. Graphs for the other subcategories are available upon request.

[22]We norm the shares of unfunded liability accrual to be as a percent of cumulative unfunded liability accrual through the FY. Un-normed percent changes in Appendix Figure C.1.

[23]See Appendix Figure B.1.

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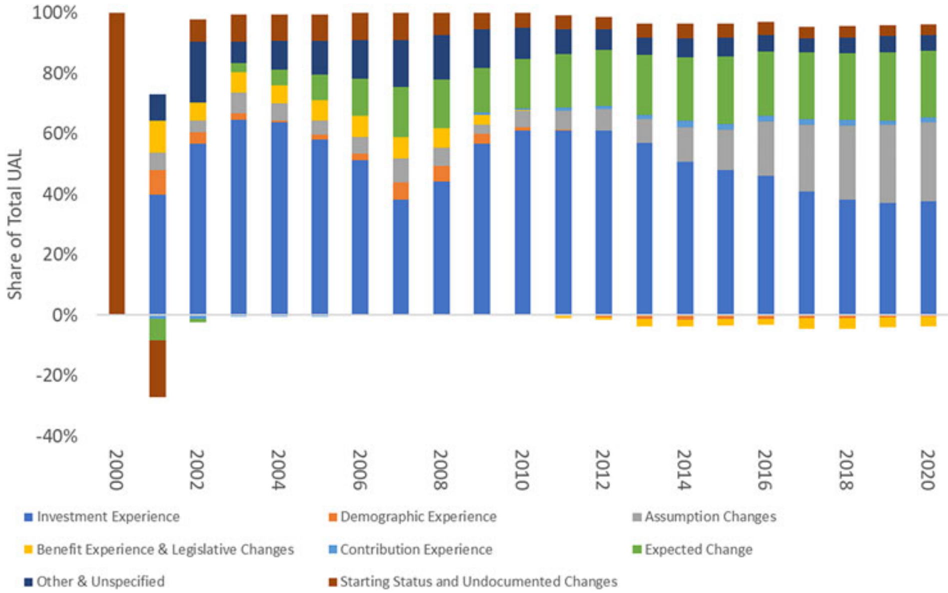

Figure 3. Sources of unfunded liabilities as a percent of total from 2000 to 2020.
Notes: Authors' tabulation of actuarial valuations and other financial reports for state-administered retirement systems using actuarial valuation of assets. Shares normed to be a percent of cumulative unfunded liability accrual through the FY. Un-normed totals in Appendix Figure B.1.

2015 and 2016 when it grew from $145.73 billion to $218.68 billion. The rise is likely due to changes to plans' assumed investment returns (UAL attributable to investment experience has fallen slightly since 2013) and more than 20 percent of plans in our dataset (20.69 percent) discounted at reduced assumed investment return rates in 2012 (which would first show up in 2013).

Benefit experience and legislative changes represents another category that has evolved over time. Over $30 billion worth of aggregate UALs were attributable to this category in 2008, but benefit experience and legislative changes represented a nearly $48 billion aggregate reduction in UAL by 2020. Most of this change is attributable to the general (unspecified) subcategory, but could be benefit formula changes and COLA changes, which account for very little of the total change on their own despite many plans making changes during the 21-year period.[24]

Contribution experience accounts for $20.65 billion in aggregate 2020 UALs, primarily driven by contribution deficiencies. This category accounted for a small cumulative reduction in UAL between 2001 and 2006, but it rose steadily until 2017. Contribution experience accounted for over $25 billion worth of UAL in 2017 but has declined in recent years because states have collectively nearly eliminated the practice of underpaying their required pension contributions and have, in some cases, been making supplemental contributions beyond what is actuarially required.

Perhaps the most constant driver of UALs is expected change (interest on the debt) which accounted for slightly less of the total UAL than assumption changes. The share attributable to interest on the debt has steadily risen since 2005. Expected changes have accounted for between 14 and 25 percent of total UAL since 2007.

The other and unspecified category as well as the starting status and undocumented changes category have accounted for a mostly constant amount of UALs since 2002.

Examining the distribution of causes of UALs over time has offered insights that were initially hidden in the original aggregate totals. While investment experience is still a substantial contributor, its

[24]See Appendix Figure B.2.

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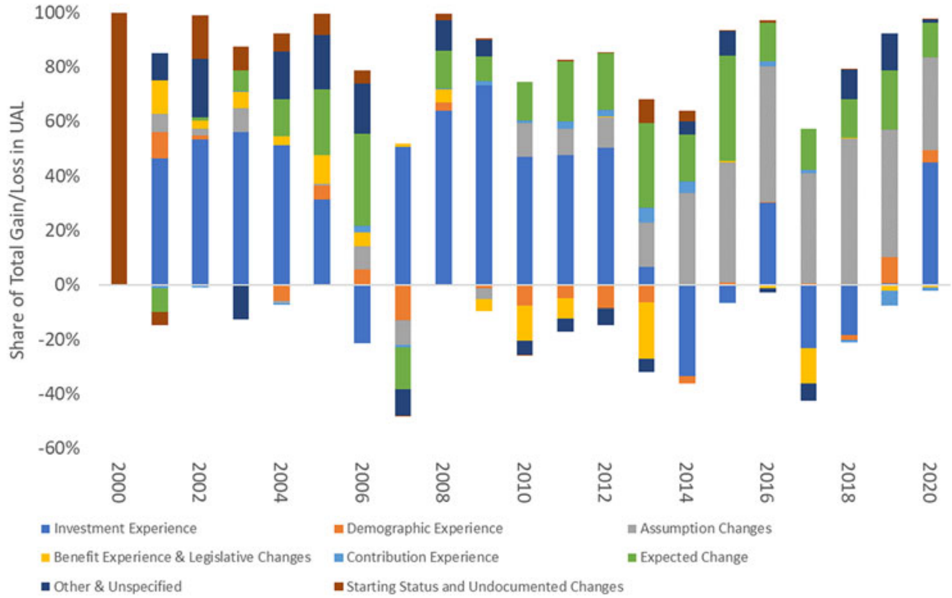

Figure 4. Sources of yearly unfunded liability accrual from 2000 to 2020.
Notes: Authors' tabulation of actuarial valuations and other financial reports for state-administered retirement systems using actuarial valuation of assets. Shares normed as a percent of the unfunded liability increase for the year. Un-normed totals in Appendix Figure B.2.

relative importance has waned in recent years. This offers some indication to how reductions in retirement systems' investment return assumptions over the past 20 years have lessened the impact of investment underperformance. However, state retirement systems would still benefit from discounting at lower assumed investment return rates more in line with market expectations. Meanwhile, the more recent increase in UAL due to expected change (interest on the debt) underscores the importance of addressing the existing UAL as something that should be addressed.

4.3 Yearly sources of unfunded liabilities

These results, so far, provide a detailed picture of the trends in UAL accumulation over time, but say comparatively little about the year-to-year differences. Figure 4 breaks down UAL gains/losses for each year and presents each primary category as a share of the yearly total gain/loss from 2000 to 2020.[25]

Prior to 2013, investment experience was the single largest annual aggregate UAL driver each year except for 2006. In fact, investment experience's yearly contribution to UAL prior to 2013 was more than double the next largest contributor except in 2005 and 2006. Between 2013 and 2019, however, the largest annual contributor was assumption changes, likely because plans began to discount at lower expected investment return assumptions.

One of the most stable year-to-year UAL contributors has been expected change (interest on the debt). Expected change has accounted for between 9 and 25 percent of yearly normed UAL gains in 11 years since 2004. One potential explanation for this consistency may be that plans rarely make immediate changes to funding policy. When states do make such changes, they are often incremental.

Benefit experience and legislative changes explain relatively little of the year-to-year change in gains/losses. Prior to 2008, this category was always associated with UAL gains, but accounts for negligible effects or a reduction in the total UAL from 2009 onwards.

[25]The shares in Figure 4 are normed as a percent of the unfunded liability increase for the year. Un-normed percent changes in Appendix Figure C.2.

4.4 Heterogeneous sources of unfunded liabilities across plans

Thus far we have focused on the aggregate trends in UAL accumulation, but this approach overlooks the heterogeneity across plans. UAL accumulation is not uniformly spread across plans and primary drivers of each plan's UAL vary. Table 3 contains summary statistics for the sources of plan UALs broken out by UAL quartile in 2020. The first four rows display statistics for each quartile.

Simply put, UALs are not equally spread across plans. The first UAL quartile includes overfunded plans and the plan at the first quartile reported just over $5 million in UALs. The plan with the most UALs in the first quartile reported less than $1 billion in UAL. UALs among plans in the second quartile vary between $798 million and over $3 billion, while the median plan reported $1.65 billion. Average UALs in the third quartile were $6.95 billion and the third quartile was less than $10 billion.

Table 3. Sources of unfunded liability accrual by plan unfunded liability quartile in 2020

UAL quartile	Mean	Minimum	Quartile 1	Median	Quartile 3	Maximum
Unfunded liabilities						
1	$225	−$652	$5	$130	$512	$768
2	$1,755	$798	$1,018	$1,651	$2,428	$3,057
3	$6,952	$3,062	$5,268	$6,432	$9,420	$11,985
4	$28,678	$12,060	$16,068	$22,728	$32,662	$105,875
Investment experience						
1	$93	−$3,519	$20	$95	$232	$1,067
2	$871	−$763	$367	$710	$1,343	$4,298
3	$3,360	−$2,962	$915	$2,925	$4,072	$22,229
4	$10,985	−$13,842	$4,079	$8,502	$16,982	$43,124
Demographic experience						
1	−$16	−$469	$0	$0	$0	$193
2	−$241	−$3,690	−$251	−$34	$0	$391
3	−$167	−$2,580	−$527	$0	$20	$1,128
4	$260	−$18,830	−$65	$161	$564	$21,803
Assumption changes						
1	$89	−$964	$1	$42	$125	$1,302
2	$529	−$1,716	$277	$461	$895	$1,618
3	$1,954	−$970	$619	$1,509	$3,038	$9,334
4	$8,114	−$5,050	$3,948	$6,889	$10,524	$38,738
Benefit and legislative changes						
1	−$52	−$1,415	−$37	$0	$4	$358
2	−$187	−$2,040	−$236	−$9	$22	$959
3	−$831	−$7,909	−$956	−$287	$24	$1,025
4	−$268	−$28,072	−$266	$137	$1,541	$8,456
Contribution experience						
1	−$4	−$196	$0	$0	$0	$132
2	$15	−$1,552	$0	$0	$38	$516
3	−$90	−$4,163	$0	$0	$0	$2,830
4	$674	−$3,945	$0	$0	$63	$16,381
Expected changes (or interest on the debt)						
1	$85	−$761	−$18	$9	$70	$2,734
2	$161	−$1,264	−$1	$153	$356	$1,200
3	$1,112	−$3,794	−$129	$848	$2,349	$6,713
4	$7,663	−$2,884	$2,325	$4,452	$7,420	$56,880
Other and unspecified						
1	−$39	−$1,079	−$86	$7	$53	$320
2	$240	−$1,489	−$23	$154	$346	$2,929
3	$365	−$10,455	−$150	$454	$1,693	$3,813
4	$1,551	−$6,024	$59	$971	$3,173	$13,195
Starting status						
1	$69	−$284	−$15	$10	$114	$909
2	$366	−$1,016	−$152	$80	$418	$3,242
3	$1,249	−$1,391	−$63	$521	$2,291	$7,784
4	−$301	−$13,555	−$3,578	−$370	$3,769	$11,405

Notes: Authors' tabulation of actuarial valuations and other financial reports for state-administered retirement systems using actuarial valuation of assets. All totals reflect millions of dollars. UAL quartiles 1, 2, and 3 $N = 36$ plans; UAL quartile 4 $N = 35$ plans.

https://doi.org/10.1017/S1474747224000064 Published online by Cambridge University Press

Plans in the fourth quartile reported UAL ranging from nearly $12 billion to over $105 billion. As a result of the skewed UAL distribution, the average total ($28.68 billion) exceeded the median ($22.72 billion) by more than 25 percent.

Additional heterogeneity becomes visible from examining the variance in the major categories between plans. For instance, despite accounting for more than 40 percent of the aggregate UAL, investment experience's cumulative role in UAL accrual across plans is much more variable than one might expect. There were plans in all four quartiles that experienced reductions in their UAL due to a positive investment experience, including one plan in the fourth quartile that had a cumulative reduction of UAL of $13.84 billion that was attributable to positive investment experience. That said, on average, plans in the fourth quartile can attribute significantly more of their UALs to investment experience with the average fourth quartile plan having accrued more than $7.62 billion more than the average third quartile plan. The magnitude of the fourth quartile is further underscored by the fact that we find that no plan in the first three quartiles had investment experiences above the median of the fourth quartile.

Across the four quartiles of UAL accrual, the distribution of plan demographic experiences tended to be symmetric and centered on $0. Once again, the scale of the fourth quartile shows itself because the average for quartiles one, two, and three were negative, while the full distribution remains centered around $0. The distributions for demographic experience indicate that, while the experience of many plans did not match expectations, the effect on UAL was variable. Above it all, plans in the fourth quartile had the most extreme experiences: one plan accumulated an $18.83 billion reduction in UAL, and another increased the UAL by $21.80 billion.

UAL experience from assumption changes generally resulted in UAL gains for plans. Across the four quartiles, the first quartile attributable to assumption changes was positive. Plans in the first two quartiles experienced maximum UALs attributable to assumption changes less than $2 billion. Similar to the other categories, plans from the fourth quartile had the largest increases in UAL because of assumption changes likely in response to their investment experiences.

Benefit experience and legislative changes tended to correspond with reductions to the UAL for most plans. The medians of quartiles one, two, and three were $0 or negative while all four quartiles had negative average UAL accrual attributable to this category. Notably, one plan experienced a reduction in the plan's UAL of $28.07 billion, despite being in the fourth quartile.

In contrast to most of the other categories, contribution experience was not very heterogeneous across plans. The first quartile and median for all four UAL quartiles were $0. The upside of this finding is that while some plans have experienced UAL gains from not paying their full actuarially required contributions, these plans seem to be exceptions.

While expected change (interest on the debt) is becoming a more prominent cause of UAL growth in the aggregate analyses, this analysis reveals that most plans have not accrued as much debt from this category as the prior results might suggest. The mean and median are positive for all four quartiles, but the variation from plan-to-plan for this category is considerable. The third quartile for plans in the fourth quartile plans was $7.42 billion and the maximum was $56.88 billion. In fact, this $56.88 billion was the largest single increase in UAL for any single plan across all the categories.

Most plans have accrued some UALs from other and unspecified sources. In addition, many plans can attribute some of their UAL to our starting status and undocumented changes categories, suggesting that they started the 2000s with at least some UAL on hand or saw increases that are not directly accounted for in their gain/loss reporting. The data indicate that increases from the other and unspecified categories were more substantial for plans in higher UAL quartiles. However, there were plans in the fourth quartile posted negative average changes to their UAL.

5. Discussion

While our analysis focuses on the top-line numbers, there are several clear lessons. First, while investment experience was the primary driver of the growth in the UAL over the last 20 years, it is important to differentiate between underperforming investments and investment losses. The nearly $540 billion worth of UAL accrual attributable to investment experience is not necessarily the result of state pension plans losing money over the past two decades. Rather, investments underperformed against expectations. This is key to the growth of UAL, whether the underperformance is due to honest asset management that could not perform due to unfavorable market conditions or due to unreasonably high investment expectations set by trustees with poor judgement or political incentives (such as avoiding cost increases). Plans have been slow to adjust their assumed investment returns, meaning that in many years they saw positive investment returns but those returns failed to perform up to the assumptions needed to meet their funding policy. As a result, state plans failed to capitalize enough on soaring financial markets between 2009 and 2019 to wipe out substantial UAL gains accrued between 2000 and 2012 (which were driven in no small part by financial losses in 2008 and 2009).

Second, increases to the UAL are not uniformly a 'bad' thing. There are several perspectives from which to interpret changes to UALs. Generally, if a goal of a DB pension plan management is to remain fully funded, UALs indicate something has gone wrong. However, while assumption changes, such as lowering the expected investment return rate and discounting at this rate, can result in increased liabilities, they also are a realization that historic assumptions are no longer adequate (or may not have been adequate for some time). Moreover, using inappropriate assumptions can result in a failure to accurately account for the true status of UALs. For example, discounting at a high investment return assumption keeps UAL 'off the actuarial books', but discounting at lower assumptions brings those costs 'on the actuarial books'. As a result, much of the $377 billion worth of UAL traced back to assumption changes should have been accounted for previously. Therefore, from the perspective of the plan's administrators, increases in reported UALs that result from improving the accuracy of the cost estimation of future guaranteed benefits are a good thing. The fact that there are UALs is not good, but a better estimate of the accrued liabilities and improved pension fund management are good things.

From another perspective, additional UALs are bad for plan management. UAL increases because of investment experience, benefit experience and legislative changes, contribution experience, or expected changes (interest on the debt) could indicate either undesirable market conditions, fund mismanagement, political mismanagement, or some combination of all of those factors.

There are also situations where UAL growth may be a problem, but it could be related to events that are viewed positively in other lights. For example, UALs that increase because of demographic experience are bad in principle (because it means that assumptions were not aligned with actual experience), but if they occur because salaries are growing faster than expected, then the additional compensation will be viewed favorably by public workers.

Also, even if UAL growth is 'bad' for plan administrators, this may not mean the trustees managing a pension fund made a mistake. Retirement system managers do not control the wages of public employees or employment decisions generally. They might align assumptions around payroll and turnover that fit both historic trends and policies of status quo state leadership. If a future set of government leaders change compensation or public employment policies in a way that translates to actuarial gain/loss, pension fund leaders should not be condemned.

Third, no assumption changes happen in a vacuum. A given state retirement plan could choose to measure the costs of benefits using a relatively conservative discount rate, even though this means higher required contribution rates, but the state legislature may be unwilling to authorize the full expense. This actuarial assumption policy is related to contribution rate deficiency that causes the UAL to increase. Another state retirement plan might maintain unrealistic mortality and investment assumptions (discounting at this rate) to keep contribution rates low, but also accumulating interest at faster rates than cash flowing into the pension plan. In this case, assumptions are related to expected change (interest on the debt) that causes the UAL to increase. In either scenario, changing actuarial assumptions will not only increase or decrease UAL, but it will also shape how other category shares of funding levels are measured.

Fourth, expected changes (interest on the debt) were responsible for over $317 billion in total UAL growth. Greater recognition of this trend by pension board trustees who set funding policy could be one of the easiest UAL contributing factors to solve for. This category represents how much actuaries would expect the UAL to increase based on funding policies even if actual experience matched perfectly with actuarial assumptions. This happens because certain funding policies use large payroll growth assumptions and/or excessive amortization periods, which generates actuarial contribution rates less than concurrently accruing interest on pre-existing UAL.[26] By virtue of paying a 'level percent of payroll', the pension fund defers paying higher contribution rates until payroll grows and pays a lower contribution rate in the interim.

Finally, there are divergent experiences across plans. The largest UAL contributor for most plans was investment experience, but its impact varied widely across plans. The average increase in UAL related to investment experience was $3.85 billion while the median plan's was $1.03 billion. There was a gap over $36 billion separating the first and 99th percentile plans on expected changes (interest on the debt) and a $28 billion gap for assumption changes.

6. Conclusion

In this paper, we use actuarial data on gains and losses to detail the financial factors that underlie $1.33 trillion worth of UALs that accrued between 2000 and 2020. This exercise shows that over 40 percent of aggregate UAL is attributable to investment experience, but that assumption changes have begun to trade off with investment experience as the primary yearly driver.

Expected changes (interest on the debt) have been a stable contributor over time to aggregate UAL and now account for nearly a quarter of the national total. We document significant heterogeneity in terms of which factors are accountable for UAL growth across plans over time.

Finally, we have also shown that certain commonly blamed factors like 'people living longer' (mortality assumptions) has not been a significant driver of the national level of UALs. Insofar as contribution experience acts as 'states not paying their bills', we have shown that states failing to make explicitly actuarially required payments has not been a substantial driver of UALs.[27] Given the heterogeneity across states these might be meaningful contributors to the UAL of certain pension plans, but they do not seem to be the key problems to be solved nationally.

While we have compiled the most robust dataset on state retirement system actuarial gain/loss data to-date, there are three key limitations of these data. First, despite including 145 state retirement plans in our data collection efforts, some plans are missing. We could not include 15 plans because of incomplete data or because the data were only for changes to contribution rates. Fortunately, the omitted plans account for less than 4 percent of aggregate UALs and our dataset covers over 96 percent of all state-administered pension fund assets nationwide. Additionally, we only include municipal plans if states administer them. For example, we included Illinois Municipal Retirement Fund in our dataset because the state of Illinois oversees the system (by setting it up in statute) whereas New York City Teachers' Retirement System was excluded because the city of New York manages this plan.

Second, these data reflect policy choices by public plan actuaries and trustees that may result in separate choices on related behavior. For example, one retirement system might lower its assumed rate of return, taking a one-time hit to their UAL measured in the assumption change category. Another retirement system might avoid those assumption-related increases to UAL, and instead have UAL grow over time measured in the investment experience category.

Finally, these data could have been miscategorized by the authors of actuarial valuations and reports that published gain/loss data in the first place. These reports are not always consistently presented from year to year, and occasionally shift categorization significantly when new actuaries take over plan valuations. The accuracy of the analysis in this paper is dependent on the accuracy of the primary source data.

[26]The average amortization period as of 2020 was 22.72 years.

[27]We could consider a wider definition of 'states not paying their bills' that would include strategies to reduce contribution rates by using high discount rates, level-percent of payroll amortization, high payroll growth assumptions, or other actuarial methods. However, we cannot distinguish where these strategies are used because plan administrators believe that they are reasonable versus where plan administrators use them to specifically reduce contemporaneous costs.

It is also separately worth noting that the dollar value and share of UAL weights in this analysis will look different once data for 2022 actuarial valuations are published. Public pension funds generated historic investment returns in 2021, averaging 24.8 percent across all state plans. Then they suffered near-historic investment losses in 2022, with the collective average still being calculated, but forecasted to be roughly minus 6 percent (Randazzo and Moody, 2022). Meanwhile, assumed rates of return have continued to decline on average, with the last major state retirement system holding on to an 8 percent return assumption (Ohio Police and Fire Pension) dropping to a 7.5 percent assumption in May 2022. The net effect of these returns will have some balancing out factors that likely will not change the overall story narrative presented in this paper where investment experience is still a major factor, but assumption changes are increasingly a cause of UAL growth.

Despite these limitations, our results have important implications for policy. First, even though the cumulative share of UAL caused by investment experience has been declining since 2012, investment experience is still the largest driver of UALs. Capital market forecasts suggest that actual investment returns over the next decade are more likely going to be around 100 basis points lower than the current level of assumed rates of return, suggesting that investment experience will continue to be among the primary causes of UAL growth, even after a historic year of investment returns. As such, policymakers for state retirement plans could mitigate some of these losses by discounting their liabilities using a more conservative investment return assumption.

Additionally, some retirement systems that receive their full actuarially required employer contribution still have considerable growth in UALs due to expected interest on their debt. These plans are effectively being implicitly underfunded. It may appear that contribution experience is not a major factor if there is no contribution rate deficiency, but failure to pay the actuarially required contribution rate is an explicit underfunding of a pension plan; using funding policies or actuarial assumptions to maintain a relatively low contribution rate that leads to expected increases in UALs is an implicit underfunding of a pension plan. In this way, paying required contributions is the bare minimum that a state legislature and participating employers should do to adequately fund a DB plan. However, it is insufficient to pay a minimum contribution rate propped up by excessively long amortization schedules or an unrealistically high assumed rate of return.[28] Policymakers can adjust their funding policy and assumptions to avoid this type of implicit underfunding.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1474747224000064

Data availability statement. The data used in this article can be obtained online from Equable Institute's website.

Acknowledgements. The authors are grateful to the Smith Richardson Foundation for financial support of this paper. The authors thank Josh McGee for his comments.

Competing interest. The authors have nothing to disclose.

References

Aaron T, Meneley B and Blake T (2022) *States' Reaffirmed Support for Teacher Pensions Underscores Exposure to Local Districts' Liabilities* (Sector In-Depth). Moody's Investor Services.

Aldeman C (2016) *The Pension Pac-Man: How Pension Debt Eats Away at Teacher Salaries* [Policy Report]. Bellwether Education Partners. https://bellwethereducation.org/sites/default/files/Teacher%20Pension%20Pac-Man_Web.pdf

Anzia SF (2020) Pensions in the trenches: how pension spending is affecting U.S. local government. *Urban Affairs Review* **58**, 3–32. https://doi.org/10.1177/1078087420964863

Anzia SF and Moe TM (2017) Polarization and policy: the politics of public-sector pensions. *Legislative Studies Quarterly* **42**, 33–62.

[28]Figure 3 from Costrell (2018) graphs level curves that display combinations of assumed investment return rates, payroll growth rates, and amortization periods. Combinations of assumed investment return rates and payroll growth rates under the level curve for a given amortization period will be subject to UAL increases resulting from interest accruing on existing unfunded liabilities (expected changes).

Aubry J-P and Munnell A (2015) Final report on Connecticut's state employees retirement system and teachers' retirement system. *Available at SSRN* 2692038.
Aubry J-P and Wandrei K (2020) *Have localities shifted away from traditional defined benefit plans?* (State and Local Pension Plans Report No. 70). Center for Retirement Research. https://crr.bc.edu/briefs/how-did-statelocal-plans-become-underfunded/
Biggs AG (2012) *Public sector pensions: how well funded are they, really?* (SSRN Scholarly Paper ID 2237647). Social Science Research Network. https://papers.ssrn.com/abstract=2237647
Boyd D and Yin Y (2018) *Investment risk and its potential consequences for teacher retirement systems and school districts* (Working Papers WR-1257; Teacher Pension Workshop: Connecting Evidence-Based Research to Pension Reform). RAND Corporation. https://www.rand.org/pubs/working_papers/WR1257.html
Bradley D, Pantzalis C and Yuan X (2016) The influence of political bias in state pension funds. *Journal of Financial Economics* **119**, 69–91.
Brainard K and Brown A (2018) *Significant reforms to state retirement systems*. National Association of State Retirement Administrators. https://www.nasra.org/reforms
Bui T, Sidorova J and Randazzo A (2022) *Best practices for pension debt amortization* (Gold Standard in Public Retirement System Design Series No. 5). Pension Integrity Project at Reason Foundation. https://reason.org/commentary/michigan-enacts-nation-leading-pension-retiree-health-care-funding-and-transparency-standards-for-local-governments/
Coggburn JD and Kearney RC (2010) Trouble keeping promises? An analysis of underfunding in state retiree benefits. *Public Administration Review* **70**, 97–108.
Costrell RM (2018) Accounting for the rise in unfunded public pension liabilities: faulty counterfactuals and the allure of simple gain/loss summations*. *Journal of Pension Economics & Finance* **17**, 23–45.
Costrell RM (2022) *Employer contributions per pupil for retirement benefits: U.S. public elementary and secondary schools, teachers & other employees*, 2004-2022. https://edre.uark.edu/_resources/pdf/costrellemployercontributionsperpupil.pdf
Costrell RM and McGee JB (2020) Sins of the past, present, and future: alternative pension funding policies. In EdWorkingPapers.com (EdWorkingPaper No. 20–272). Annenberg Institute at Brown University. https://www.edworkingpapers.com/ai20-272
Doherty KM, Jacobs S and Madden TM (2012) *No one benefits: how teacher pension systems are failing both teachers and taxpayers*. National Council on Teacher Quality. https://www.nctq.org/publications/No-One-Benefits:-How-Teacher-Pension-Systems-are-Failing-BOTH-Teachers-and-Taxpayers
Elder EM and Wagner GA (2015) Political effects on pension underfunding. *Economics & Politics* **27**, 1–27.
Fuchsman D, McGee JB and Zamarro G (2023) Teachers' willingness to pay for retirement benefits: a national stated preferences experiment. *Economics of Education Review* **92**, 102349.
Hawkins M (2022) Public pensions face worst funding decline since Great Recession. *Bloomberg.Com*. https://www.bloomberg.com/news/articles/2022-07-22/public-pensions-face-worst-funding-decline-since-great-recession
Kim D, Koedel C and Xiang PB (2020) The trade-off between pension costs and salary expenditures in the public sector. *Journal of Pension Economics & Finance* **20**, 1–18. https://doi.org/10.1017/S1474747219000362
Koedel C (2019) California's pension debt is harming teachers and students now – and it's going to get worse. *Brookings*. https://www.brookings.edu/blog/brown-center-chalkboard/2019/05/03/californias-pension-debt-is-harming-teachers-and-students-now-and-its-going-to-get-worse/
Marcus S (2015) How did N.J. get into this pension mess? *NJ.Com*. https://www.nj.com/politics/2015/01/how_did_nj_get_into_this_pension_mess.html
Mayo R and Caskey M (2021) *Annual Survey of Public Pensions:* 2020. Washington, DC: U.S. Census Bureau.
McGee JB (2016) *Feeling the Squeeze: Pension Costs Are Crowding Out Education Spending* (No. 22). Washington, DC: Manhattan Institute. https://www.manhattan-institute.org/html/feeling-squeeze-pension-costs-are-crowding-out-education-spending-9368.html
McGee JB (2017) McGee: pension plan fix is a sign of progress. *Houston Chronicle*. https://www.houstonchronicle.com/opinion/outlook/article/McGee-Pension-plan-fix-is-a-sign-of-progress-11206832.php
Melnicoe H, Hahnel C, Koedel C and Ramanathan A (2019) *The big squeeze: how pension costs threaten educational equity* [Research Report]. Pivot Learning. https://www.pivotlearning.org/resources/big-squeeze-how-pension-costs-threaten-educational-equity/
Moody J and Randazzo A (2020) *Hidden education funding cuts: how growing teacher pension debt is eating into K-12 education budgets* [Equable Institute Research Report]. Equable Institute. https://equable.org/wp-content/uploads/2020/04/National-Paper_Hidden-Funding-Cuts_Final.pdf
Moody J, Randazzo A and Diaz Aguirre P (2022). *The national landscape of teacher retirement benefit security* [Equable Institute Research Report]. Equable Institute. https://equable.org/wp-content/uploads/2020/04/National-Paper_Hidden-Funding-Cuts_Final.pdf
Munnell AH, Aubry J-P and Cafarelli M (2015) *How did state/local plans become underfunded?* (State and Local Pension Plans Report No. 42). Center for Retirement Research. https://crr.bc.edu/briefs/how-did-statelocal-plans-become-underfunded/

Nation J (2018) *Pension math: public pension spending and service crowd out in California*, 2003-2030 (Working Paper No. 17–023). Stanford Institute for Economic Policy Research. https://siepr.stanford.edu/research/publications/pension-math-public-pension-spending-and-service-crowd-out-california-2003

Novy-Marx R (2015) Economic and financial approaches to valuing pension liabilities*. *Journal of Pension Economics & Finance* **14**, 144–150.

Novy-Marx R and Rauh J (2011) Public pension promises: how big are they and what are they worth? *The Journal of Finance* **66**, 1211–1249.

Randazzo A (2017) There is a tangled web of factors causing inappropriate pension funding behavior. *Journal of Law, Economics & Policy* **14**(1), 107–126.

Randazzo A and Moody J (2022) *State of Pensions* 2022 [Report]. Equable Institute. https://equable.org/state-of-pensions-2022/

Randazzo A, Gilroy L and Niraula A (2016) *South Carolina pension reform analysis*. https://reason.org/wp-content/uploads/files/south_carolina_scrs_pension_reform_analysis_2016oct25.pdf

Randazzo A, Gilroy L and Christensen Z (2018a) *Colorado Adopts Significant Pension Changes for All Public Employees*. Washington, DC: Reason Foundation. https://reason.org/commentary/colorado-adopts-significant-pension-changes-for-all-public-employees/

Randazzo A, Gilroy L and Takash D (2018b) *Michigan Enacts Nation-Leading Pension, Retiree Health Care Funding and Transparency Standards for Local Governments*. Washington, DC: Reason Foundation. https://reason.org/commentary/michigan-enacts-nation-leading-pension-retiree-health-care-funding-and-transparency-standards-for-local-governments/

Smith DJ and Dove JA (2016) *The economic consequences of pension underfunding: evidence from the retirement systems of Alabama* (SSRN Scholarly Paper ID 2795692). Social Science Research Network. https://doi.org/10.2139/ssrn.2795692

Social Security Administration (n.d.) *Fast facts & figures about social security*, 2021. Social Security Administration Research, Statistics, and Policy Analysis. Retrieved May 9, 2023, from https://www.ssa.gov/policy/docs/chartbooks/fast_facts/2021/fast_facts21.html#pagei

State of Illinois Retirement Systems: Funding History and Reform Proposals (2008) [A civic federation issue brief]. The Civic Federation. https://www.civicfed.org/civic-federation/publications/state-illinois-retirement-systems-funding-history-and-reform-proposal-0

Stein B, Biggs AG, Elliott DJ, Belt B, Bilyeu DK, Crane D, Hamilton M, Msall L, Musuraca M, North B, Ravitch R and Zimpleman LD (2014) *Report of the Blue Ribbon Panel on public pension plan funding*. Society of Actuaries.

Takash D, Gilroy L, Randazzo A and Quintero J (2018) *Evaluating Solutions for Austin's Billion Dollar Pension Crisis* [Policy Brief]. Austin, TX: Texas Policy Foundation. https://reason.org/policy-brief/evaluating-solutions-for-austins-billion-dollar-pension-crisis/

Thom M (2013) All of the above: how fiscal, political, and workforce traits affect pension funding. *State and Local Government Review* **45**, 163–171.

Thom M and Randazzo A (2015) Underfunding annual pension contributions: examining the factors behind an ongoing fiscal phenomenon. *State and Local Government Review* **47**, 35–44.

Yang T and Mitchell O (2005) Public pension governance, funding, and performance: a longitudinal appraisal. *Wharton Pension Research Council Working Papers*. https://repository.upenn.edu/prc_papers/376

Cite this article: Fuchsman D, Hengerer D, Moody J and Randazzo A (2024) The actuarial sources of the rise in unfunded liabilities in America's defined benefit plans in the 21st century. *Journal of Pension Economics and Finance* 1–21. https://doi.org/10.1017/S1474747224000064