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Public Pension Risk-Sharing Mechanisms and Their Potential Impacts

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ABSTRACT

With increasing costs and risks in public defined-benefit pension plans, state and local governments have sought to share investment, inflation and longevity risks with employees. Risk sharing could protect employers from cost increases and reduce contribution volatility, but it could also create benefit risk or increase contribution burden for employees. Designing appropriate risk-sharing policies requires a good understanding of how these policies affect costs and benefits and the volatility of each. In this paper, we use a stochastic pension simulation model applied to a prototypical pension plan to examine the impact of selected risk-sharing mechanisms styled after mechanisms currently used by some U.S. state pension plans. We found that the stylized contingent cost-of-living adjustments (COLA) triggered by investment returns or funded ratios reduce the overall volatility of employer contributions only marginally, while the impact of these policies is more significant during dramatic market downturns. These contingent COLA policies can create significant benefit risk for retirees. The contingent employee contribution policy we examined has relatively little impact on employer contribution volatility and the total employer cost. A complex policy styled loosely after the South Dakota Retirement System (SDRS) risk-sharing arrangement has much bigger impacts. The extent of these impacts is highly dependent on corrective actions to pay the unfunded liabilities when full funding cannot be achieved by adjusting COLA. Our results also show that the specific design of a risk-sharing policy will have large effects on its impact. The acceptance of contingent COLA and contribution policies will depend on the risk tolerances and preferences of plan sponsors and plan members.

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Summary

In traditional public sector defined benefit plans, the employer bears nearly all investment risk, longevity risk, and inflation risk during plan members' working years and in retirement years. In traditional defined contribution plans, members bear nearly all these risks. Some pension plans incorporate risk-sharing policies, under which the employer and plan members each bear some risks, either through specific benefit or contribution mechanisms built into defined benefit plans or through a hybrid combination of defined-benefit and defined-contribution plan features. More governments may seek risk-sharing policies in the future to reduce plan costs and risks. This paper examines selected risk-sharing mechanisms of public sector defined benefit plans.

Any of the risks borne by employers can be converted to risks borne by workers or retirees through adjustments to employee contributions or to benefits (typically by adjusting COLAs), creating contribution or benefit risk for members. Adjustments to employee contributions affect members during working years and COLA adjustments affect members in retirement years. Benefit adjustments usually have limits to prevent a member's benefit from being reduced below either the prior year's benefit or the initial benefit at retirement.

Risk-sharing usually is triggered by plan performance that is worse or better than assumed by the actuary. Two common triggers are funded ratios and investment returns. Funded-ratio triggers can convert almost any risk borne by the employer to risk borne by plan members - for example, unexpected results for investment returns, longevity, or inflation all affect either assets or liability, and therefore funded ratios. By contrast, investment-return triggers can transfer investment risk to plan members, but they do not transfer longevity or inflation risks to members. In practice this difference may not be great because investment risk typically is the largest risk. In their simplest forms, funded-ratio triggers can cause less volatility than investment-return triggers because after a funded ratio falls below target, it may take years to climb back above the target; an investment-return trigger based on annual returns could cause adjustments every year, but this can be smoothed with more-complex triggers based on returns averaged over several years.

Risk sharing can protect employers from dramatic cost increases and contribution volatility, but it can cause lower benefits or higher contributions over the long term for plan members and make their benefits and contributions more volatile as well. Designing appropriate risk-sharing policies requires understanding how these policies affect costs and benefits and the volatility of each.

The impacts of risk-sharing policies depend upon uncertain future events, particularly investment returns. These impacts are best understood with models that take investment-return volatility into account. Very little existing research has examined risk-sharing policies in this way.

We examine the impacts of selected risk-sharing policies on employers and plan members, using a model that simulates a pension fund's year-by-year finances taking investment return volatility into account (i.e., a stochastic simulation model). The pension plan we model has demographic characteristics of a stylized typical U.S. public pension plan. We assume that it has reached a steady state, with new members each year replacing leaving members in a way that keeps the plan's overall demographic structure stable; this assumption greatly simplifies our calculations while still allowing valuable insights.

To run the model, we specify (1) benefit policies that determine annual benefit payouts, (2) investment return assumptions that determine annual investment returns and income, and (3) funding and contribution policies that determine contribution inflows. The baseline benefit policy includes a 1.5 percent annual COLA. Inflation is assumed to be 2 percent annually, and thus the baseline policy does not keep up with inflation. We describe asset-return assumptions below. In our baseline runs, employees contribute 6 percent of payroll and the employer pays the remainder of normal cost and amortizes investment gains or losses over 15 years with 5-year asset smoothing. We calculate the plan's funded ratio and other measures each year.

A 40-year run of the model starting from a fully funded position constitutes a single "lifetime" for the pension fund. First, we examine a deterministic "shock" scenario in which asset values fall sharply before recovering. After that, we examine stochastic scenarios in which we run the model for 1,000 lifetimes, with investment returns varying within a single lifetime and across lifetimes. We draw returns from a normal distribution with expected compound return of 7.5 percent and a standard deviation of 12 percent.

We examine contribution and benefit costs and risks for six stylized risk-sharing policies inspired by actual policies in use.

- Three contingent COLA policies:
    - *Contingent COLA: return*. 2 percent COLA if prior-year investment return was 7.5 percent or greater, 0 percent otherwise. Similar to COLAs in several Maryland retirement systems.
    - *Contingent COLA: Funded ratio threshold*. 2 percent COLA if prior-year funded ratio was 90 percent or higher, 0 percent otherwise. Similar to a policy in the Arizona State Retirement System.
    - *Contingent COLA: Funded ratio ramp*. 2 percent COLA if prior-year funded ratio was 90 percent or higher; 0 percent if funded ratio was below 70 percent; prorated COLA between 70 percent and 90 percent. Similar to a policy in the Montana Public Employees Retirement System.

  If plan assumptions are always met, all three contingent COLAs will always be 2 percent and will provide greater benefit, at greater cost, than the baseline 1.5 percent COLA.

- Two complex COLA policies loosely styled after South Dakota Retirement System (SDRS) policies: Adjust the COLA annually to achieve full funding, limited by a 0 percent floor and a 2 percent ceiling. If a 0 percent COLA cannot achieve full funding, require corrective action by policymakers. We designed two hypothetical corrective actions:
    - *SDRS slow repayment*. 15-year open level-dollar amortization of shortfall, with equal employer and employee contribution increases
    - *SDRS fast repayment*. Same as above, but 5-year amortization

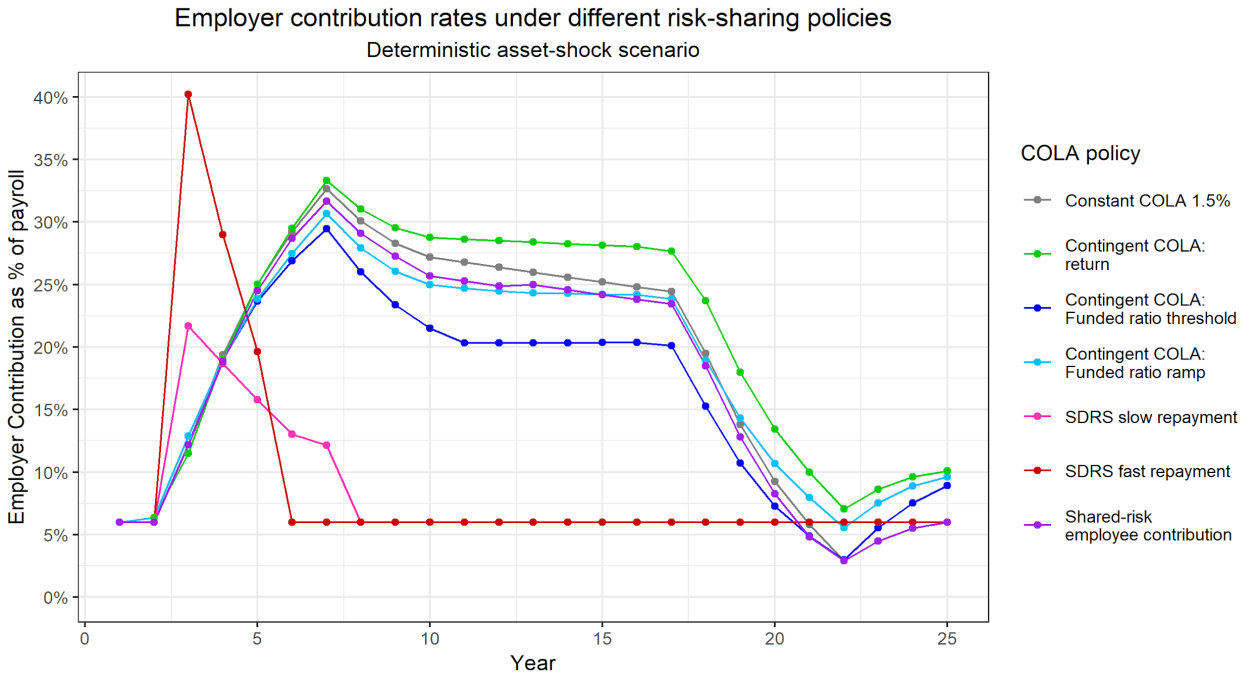
- One contingent employee contribution policy:
    - *Shared-risk employee contribution*. COLA is 1.5 percent every year. Employee contribution is adjusted every 3 years by plus or minus 0.5 percent of pay based on prior 10-year returns. Maximum total adjustment is plus or minus 2 percent of pay.

A deterministic asset-shock scenario

We examined an asset shock scenario with a 24 percent investment loss in year 2 followed by a three-year recovery with annual returns around 12 percent, after which returns are a constant 7.5 percent. Figure 1 shows the impact on employer contributions.

None of the policies prevented a sharp spike in employer contributions. The two SDRS-like policies could not achieve full funding even with zero COLAs and so the corrective action requirement was triggered. Under our assumptions (which are not intended to predict what South Dakota might do in such a situation), the corrective actions caused both employer contributions and employee contributions (not shown) to rise sharply. Among other policies, the two with a funded-ratio trigger caused the largest contribution reduction. The "Contingent COLA: funded ratio threshold" policy had the strongest cost-reducing and volatility-damping effects because the funded ratio was driven down so far below the 90 percent threshold that it provided zero COLA for 8 years after the asset shock. The "ramp" policy had a far more modest effect on employer contributions. The COLA contingent upon annual investments return showed minimal effect under this asset-shock scenario because only one year's COLA is affected. However, a return-based COLA policy can have significant effects in stochastic scenarios, where investment returns vary considerably from year to year.

Figure 1. Employer contribution rates under asset shock scenario



Stochastic scenarios

Table 1 summarizes important results from our stochastic analysis. The rows show the baseline policy (1.5 percent COLA every year - in gray) and the six risk-sharing policies we examined. Notes at the bottom of the table describe each policy briefly.

The columns are divided into two main blocks that summarize the impacts on employers and members, respectively. (For members, we focus on the impact over the lifetime for a single cohort, to avoid mixing cohorts. That issue does not arise with employers because the employer lives forever in our model.) The blocks show, respectively, the cost of employer contributions and their short-term volatility, and the lifetime value of member benefits and the short-term benefit volatility.

- Employer contributions:
    - *Cost to the employer:* The two columns in this subgroup show the present value of employer contributions indexed to present value contribution cost of the baseline policy in the median simulation. The left column shows the present value at the median simulation, and the right column shows the value at the 90th percentile (a more-expensive scenario for the employer, a good scenario for members).
    - *Short-term volatility of employer contributions:* The two columns in this subgroup show the maximum increase in contributions that the employer faced in any 5-year period in our simulations, as a percentage of payroll, in the median simulation run and at the 90th percentile.
- Member benefits for a single cohort:
    - *Lifetime value of benefits:* The two columns in this subgroup show the present value of benefits over a single cohort's lifetime indexed to the present value for the baseline policy in the median simulation. The left column shows the present value at the median simulation, and the right column shows the value at the 10th percentile (a bad scenario for the member, a less-expensive scenario for the employer).
    - *Short-term volatility of member benefits:* The two columns show the maximum decrease in benefits that the cohort faced in any 5-year period of our simulations, as a percentage of payroll, in the median simulation run and at the 10th percentile.

Table 1. Summary of key results

Comparison of shared-risk policies analyzed in this paper

Selected results from stochastic simulations

	Impact on employer contributions				Impact on benefits for a single cohort			
	Present value of employer contributions		Maximum increase as % of payroll, any 5-year period		Present value of lifetime benefit		Maximum % decrease in inflation-adjusted benefit, any 5-year period	
Policy	Median	90th percentile	Median	90th percentile	Median	10th percentile	Median	10th percentile
(a) Constant COLA 1.5% (baseline)	100	223	32%	72%	100	100	(2.4)	(2.4)
Contingent COLA policies								
(b) Contingent COLA: return	88	198	29%	69%	95	93	(7.5)	(8.9)
(c) Contingent COLA: funded ratio threshold	95	193	29%	71%	101	91	(8.2)	(9.4)
(d) Contingent COLA: funded ratio ramp	104	205	30%	70%	104	95	(4.6)	(9.1)
Policies styled after South Dakota Retirement System (SDRS)								
(e) SDRS slow repayment	66	112	12%	19%	99	91	(8.2)	(9.3)
(f) SDRS fast repayment	72	128	23%	36%	100	93	(7.4)	(9.2)
Contingent employee contribution								
(g) Shared-risk employee contribution	101	216	31%	73%	*	*	*	*

Policy descriptions

(a) Constant COLA 1.5% -- fixed 1.5% annual COLA; the baseline against which we compare other policies

(b) Contingent COLA: return -- 0% COLA when prior-year investment return < 7.5%, 2% when prior return >= 7.5%

(c) Contingent COLA: funded ratio threshold -- 0% COLA when prior-year funded ratio < 90%, 2% when prior ratio >= 90%

(d) Contingent COLA: funded ratio ramp -- 0% when prior-year funded ratio < 70%, 0 to 2% as ratio rises to 90%, 2% when ratio >= 90%

The 2 policies styled on the South Dakota Retirement System have 1.5% baseline COLA, 0% floor & 2% ceiling. The assumed corrective actions differ:

(e) SDRS slow repayment. 15-year open level-dollar amortization of shortfall, with equal employer and employee contribution increases

(f) SDRS fast repayment. 5-year open level-dollar amortization of shortfall, with equal employer and employee contribution increases

(g) Shared-risk employee contribution -- COLA is 1.5% every year. Employee contribution is adjusted every 3 years +/- 0.5% of pay based on 10-year returns. Maximum total adjustment +/- 2% of pay.

* Benefits are same as in baseline policy, but employee contribution costs are different.

Looking down the left column of any two-column group shows how a risk-sharing policy compares to the baseline policy in the first row. Comparing the left and right columns in the group shows what happens as we move from the median or typical simulation to a bad scenario (here defined as the 90th percentile for employers and the 10th percentile for plan members). The body of the paper examines these and other measures in detail. Here we summarize key conclusions.

Contingent COLA policies:

- Moderate protection against high employer cost in bad return scenarios: Compared to the baseline policy, all three contingent COLA policies lead to lower present value of employer contributions in bad scenarios - their present value, at the 90th percentile, is well below the baseline policy present value. Their value at the median is closer to the baseline than it is in bad scenarios.
- Little protection against short-term employer contribution volatility: The baseline policy's worst-5-year-increase in employer contributions is 32 percent of payroll in the median simulation and 72 percent at the 90th percentile, more than doubling in bad-return scenarios. The worst-5-year increases are similar for the contingent COLA policies - they provide little protection against short-term volatility.
- Members face risk of substantially lower benefits over their lifetimes and over short time periods: Comparing the median and 10th percentile columns shows that the two policies triggered by low funded ratios can result in substantially lower lifetime benefits in bad scenarios. Furthermore, benefit reductions can come relatively quickly - at the 10th percentile, all three policies lead to declines of 9 percent in inflation-adjusted benefits within a 5-year period. These policies also entail upside potential for members, as the body of the paper discusses.

Policies styled after South Dakota Retirement System COLA policies:

These policies have lower employer contribution cost and lower employer contribution volatility than the other risk-sharing policies. While benefit risk to members is not much greater than in the other risk-sharing policies, this tells only part of the story. When these policies cannot achieve full funding through COLA reductions, corrective action is required. Our analysis assumes that contribution increases would be required of both employers and employees. Because corrective action often will be required, members will face both benefit-reduction risk and contribution-increase risk. The impact of the policies is highly dependent on assumptions about who will bear the impact of corrective actions and over what time period.

The contingent employee contributions policy:

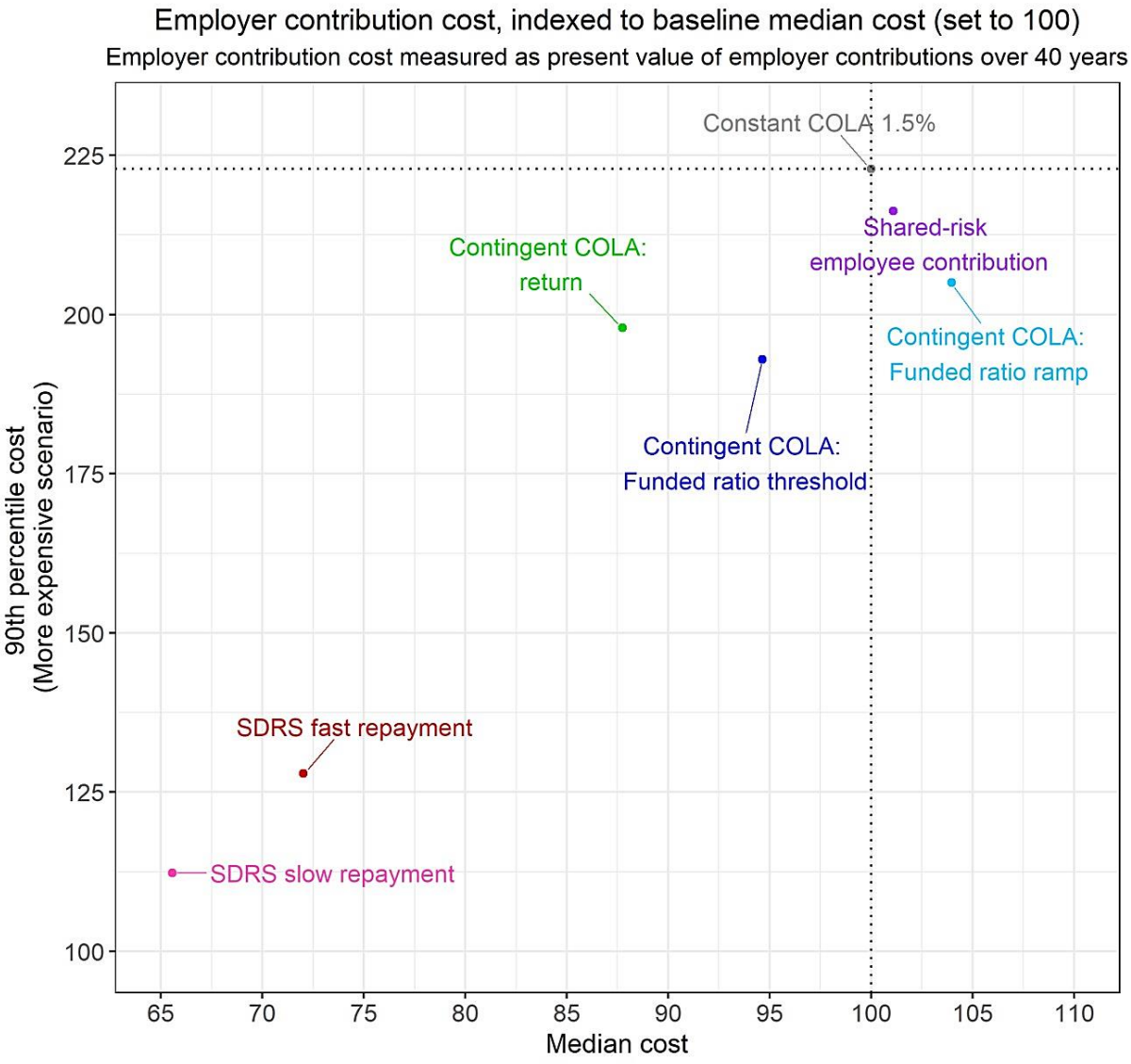
The contingent employee contributions policy we examined had relatively little impact on employer contribution volatility and total employer cost. They have no impact on member benefits but increase member contribution cost. We will examine the costs and risks to members of contingent employee contributions in future work.

Illustrations of impacts on employers

Figure 2 summarizes the present value of employer contribution costs at the median and 90th percentiles, indexed to the median baseline cost. It shows that all of the risk-sharing policies we examined are less expensive than the baseline in adverse circumstances (at the 90th percentile -- they fall below the dotted

horizontal line); nonetheless, several are more expensive than the baseline at the median outcome (to the right of the dotted vertical line).

Figure 2. Present value of employer contributions



Most of the policies would have little impact on the short-term volatility of employer contributions. The major exceptions are the two policies styled after the South Dakota Retirement System (SDRS) policy, striving to maintain full funding through annual adjustments to COLAs.

Figure 3 shows the maximum employer contribution increase in any 5-year period over our 40-year simulations, under each policy, at the median simulation out of 1,000 simulations and at the 90th percentile. The SDRS-like policies have much smaller maximum employer contribution increases than all the other policies.

Figure 3. Maximum employer contribution increase in a 5-year period

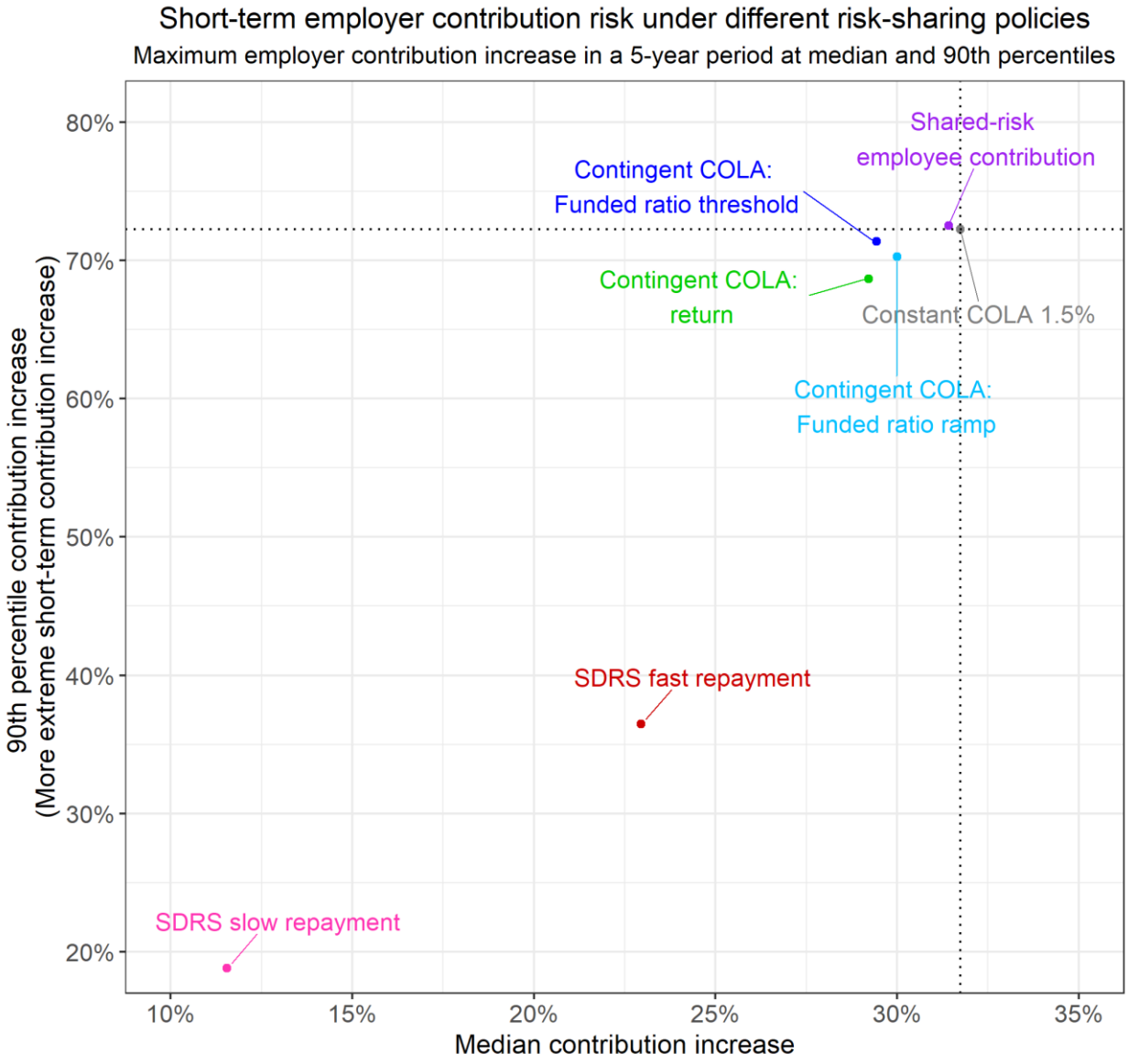
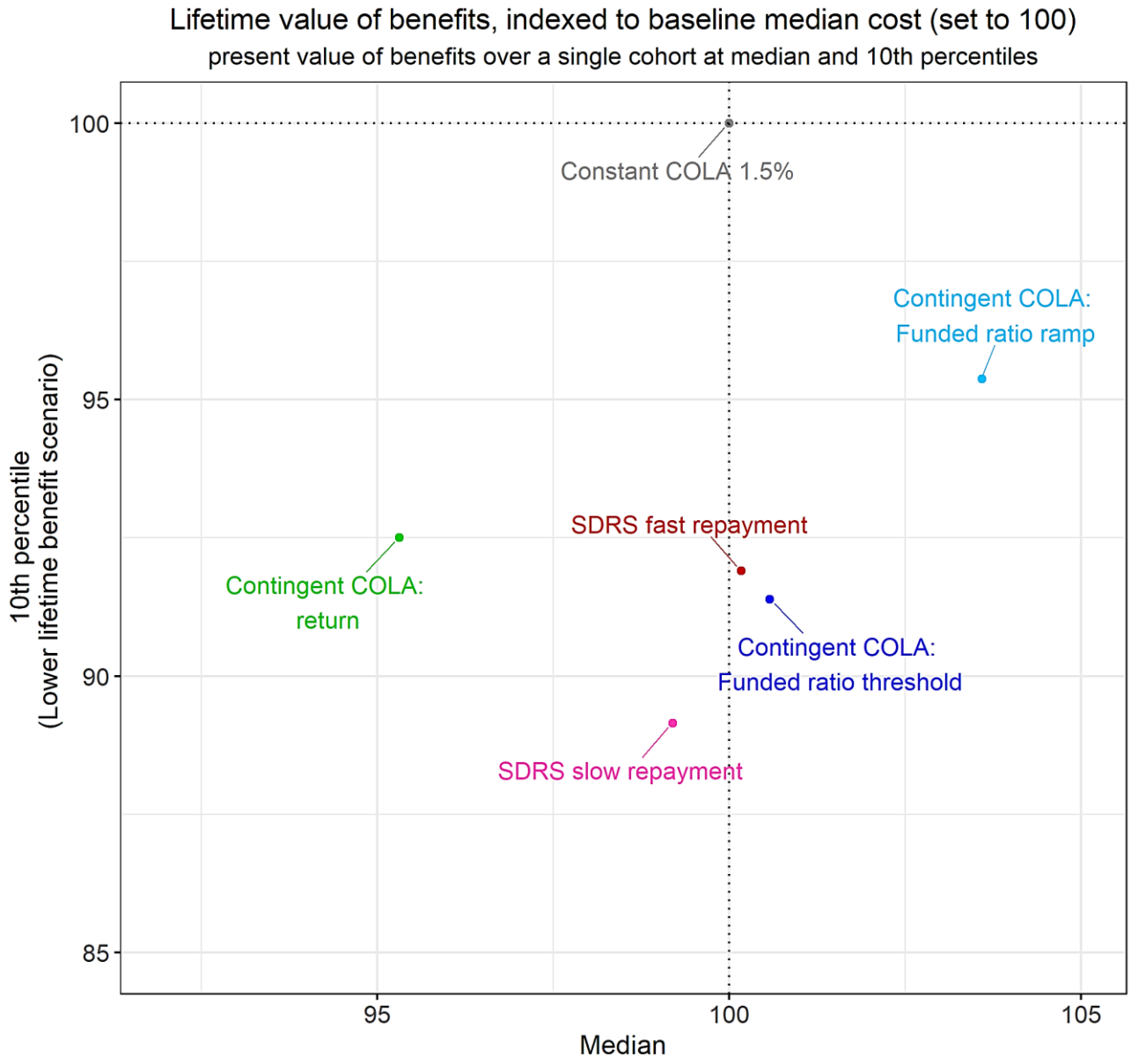


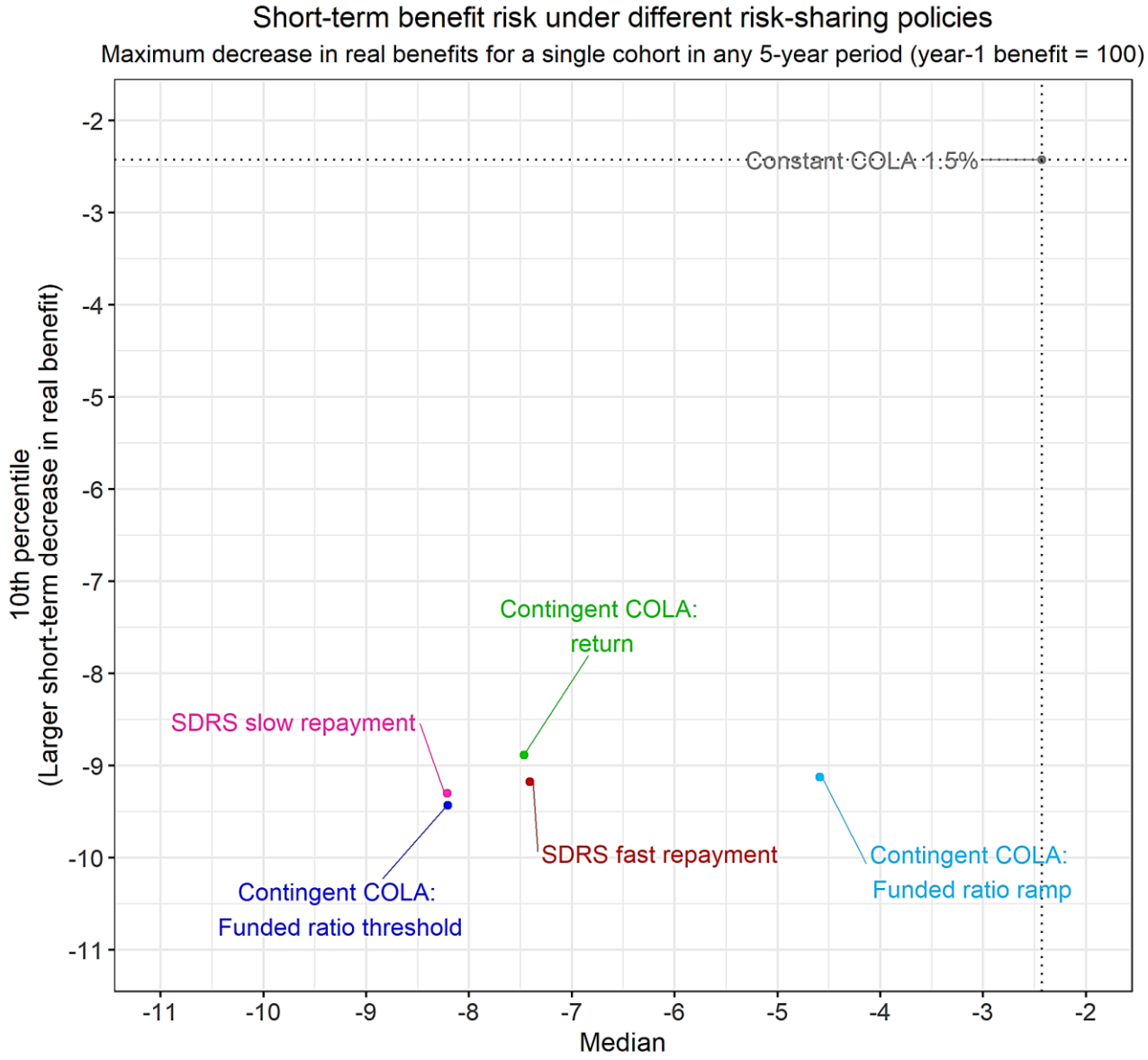
Figure 4 summarizes the lifetime value of benefits at the median and 10th percentiles, indexed to the median benefit value under the baseline policy. The contingent employee contribution policy does not affect benefits and is therefore excluded from this figure. The figure shows that the policies we examined lead to substantial risk of low benefit values compared to the baseline in adverse circumstances (see the 10th percentiles, which are lower than the dotted horizontal line by 5 to 11 percentage points). At the median outcome, several policies provide higher lifetime value of benefits than the baseline (to the right of the dotted vertical line).

Figure 4. Present value of lifetime benefits for a single cohort



Retirees also face substantial risk that the real value of benefits will fall quickly in a short period of time under all the policies we examined. Figure 5 shows the maximum decrease in inflation-adjusted benefit for a single cohort in any 5-year period over our 40-year simulations, under each policy, at the median simulation out of 1,000 simulations and at the 90th percentile. The benefit in the first year of retirement is indexed to 100. In adverse circumstances (10th percentiles), all policies can lead to losses of purchasing power of about 9 percent of the initial benefit within a 5-year period. At the median outcomes, the maximum 5-year decline in real benefit ranges from 4.5 percent to 8 percent of the year-1 benefit.

Figure 5. Maximum decrease in real benefits for a single cohort in any 5-year period



Overall conclusions

We consider our simulation results preliminary but informative. Our main conclusions are:

- The contingent COLA policies we examined, other than the stylized SDRS-like policies, reduce the volatility of employer contributions only marginally. The impact of these policies is more significant during dramatic market downturns than during more-normal market conditions.
- The contingent COLAs we examined could create a significant benefit risk for retirees. During downturns, retirees could experience low benefits during retirement. The acceptance of contingent COLA policies depends on the risk tolerance and risk preference of plan members and policymakers.
- The contingent employee contributions policy we examined, styled after policies in Pennsylvania state retirement systems, also has relatively little impact on employer contribution volatility and total employer cost.
- The complex policies styled loosely after the South Dakota Retirement System risk sharing arrangement, which seek to achieve full funding by adjusting the COLA within a ceiling and a floor, have much bigger impacts. They have lower employer costs and risks than the other risk-sharing policies we examined. These policies require "corrective action" if full funding cannot be achieved at the floor COLA. The impact of the policies is highly dependent on these corrective actions; we modeled two hypothetical actions that split the shortfall 50-50 between employers and employees.
- Put simply, the specific design of a risk-sharing policy will have large effects on its impact.
- Finally, in some instances, introduction of a risk-sharing policy when a plan is deeply underfunded may be less about reducing risk and more about reducing cost: a policy that provides some benefit upside potential but substantial downside, with a COLA floor of zero, may be intended to reduce costs and benefits substantially relative to a fixed COLA. In addition, employers may utilize the interaction between risk-sharing mechanisms and other plan policies to further reduce cost. For example, the funded-ratio-triggered COLA policies can create incentive for employers to seek a lower discount rate: the lower discount rate would result in higher actuarial liability and a lower funded ratio, making COLAs less likely to be triggered and therefore reducing future benefit payouts. It also could make it easier for a plan to take less investment risk.

1. Introduction

In traditional public sector defined benefit (DB) plans, the employer generally bears nearly all investment risk, longevity risk, and inflation risk during both working years and retirement years. In traditional defined contribution (DC) plans, employees bear nearly all these risks. With increasing costs and risks in DB plans, state and local governments have sought to use various approaches to share one or more of these risks with employees, during working years or retirement years or both. Risk-sharing can be done through mechanisms such as contingent cost-of-living adjustments (COLAs), contingent employee contributions, or hybrid DB-DC plans.

Risk sharing has not been widely used in U.S. public pension plans. Several state pension plans have introduced contingent COLAs and contingent employee contributions in recent years. For example, COLAs in South Dakota Retirement System depend partly on plan funded status, COLAs in Wisconsin Retirement System depend upon investment performance, and employee contributions in Pennsylvania State Employees' Retirement System depend partly upon investment performance.[1] Many variants and alternative approaches to risk-sharing are possible.

As governments seek ways to control pension costs and risks while providing competitive compensation to public employees, it will be increasingly important to understand how risk-sharing mechanisms affect costs and risks to pension plans, governmental employers, workers, and retirees. These costs and risks depend upon uncertain future events and are best analyzed with methods that take their probabilistic nature into account.

In this paper, we use a steady-state stochastic simulation model applied to a prototypical pension plan to examine two risk-sharing mechanisms more deeply: (1) adjustments to COLAs, which affect retirement years, and (2) adjustments to employee and employer contributions, which affect working years. We examine how these mechanisms affect costs and risks to plans and employers, how they affect the benefits and income of employees, and how they alter risks to employer contributions, retiree benefits, employee contributions, and plan funded status.

This paper is organized as follows: (1) literature review, (2) methods, (3) analysis of three major kinds of risk-sharing policies independently (a) contingent COLAs, (b) COLA policies that seek full funding each year, styled after South Dakota Retirement System policies, and (c) contingent employee contributions, (4) a summary of key results looking across all risk-sharing policies examined, and (5) overall conclusions.

2. Literature review

2.1 Risk management in public pension plans

Pension plans are exposed to several main risks, including *investment risk*, *inflation risk, longevity risk,* and *solvency risk* (Blome 2007). Investment risk is the uncertainty of gains or losses from pension investments. Inflation risk is the chance that the prices of goods will grow faster than pension benefits. Longevity risk is the risk that retirees will live longer than their projected benefits. Solvency risk is the risk that pension assets are insufficient to cover promised benefits. Besides, pension beneficiaries also bear

benefit risk, which is the uncertainty of benefit amount received by retirees. Pension system sponsors bear the *contribution risk*, which is the uncertainty of contribution amount that is required to be paid by employers. In public pension plans, employer contributions will crowd out other public spending or demand more government revenues. Contribution risk for governments can become a risk for taxpayers.

Risk evaluation and management are becoming more important for public pension plans in recent years (AAA, 2010). Research shows that public pension plans increasingly take higher investment risks by shifting more investments to equities (Boyd and Yin 2017). Insufficient contributions and inappropriate benefit designs further add to the level of solvency risks for pension plans. Recent efforts have assessed the appropriate level of risks for public plans and provide policy advice to better communicate risks with stakeholders of public pensions (Boyd and Yin 2017).

From the risk management perspective, risks can be mitigated through appropriate "plan design or benefit structure, financing structures, self-adjusting systems, pooling, multiple entity arrangements, third-party guarantees, and backup guarantee funds." (Rappaport and Peterson 2014) One of the risk mitigation strategies is to share risks among employers and employees, which can be achieved by the design of pension benefit policies or contribution policies.

2.2 Risk-sharing between employees and employers

The distribution of risks between employers and employees is different between DB and DC plans. In a traditional DB plan, employees are promised guaranteed benefits based on a preset benefit formula plus fixed COLAs regardless of investment returns. The benefit risk, inflation risk, and longevity risk for employees participating in DB plans are minimal. DB plan employers are fully responsible for investment risk and contribution risk. DB plans also face solvency risk when their funded ratios fall below a certain level. In a traditional DC plan, employers are only responsible for making a fixed contribution to the employees' pension accounts. Employees participating in DC plans receive benefits depending on the contributions and investment returns accumulated in individual retirement accounts. Therefore, investment and inflation risks are borne by employees.

Because of the increasing costs and risks of public DB pension plans, governments have explored many options to share risks with employees with the goal of lowering risks, costs and liabilities. The basic idea of risk-sharing is to change the benefit rules or contribution rules that guarantee the employees' benefits and/or contributions. Instead, employees' benefits and/or contributions are linked to certain levels of investment performance or funding performance. Risk-sharing can help to build a more sustainable plan, not just because of lowering budgetary burdens of pension plans to governments, but also because through risk-sharing, both the contribution volatility for the employer and the solvency risk for the plan can be decreased. The impacts of risk-sharing on employees' benefits, employers' contributions, their volatility, and the solvency measurement of the plan are examined in this research through stochastic simulations.

2.3 Mechanisms for risk sharing

Depending on how the benefits are linked with performance, there are three main types of risk-sharing mechanisms: contingent COLAs, contingent contributions, and plans with DB and DC features (Pugh and Yermo 2008; NASRA 2019).

Contingent COLAs link the post-retirement benefit increase with investment or funding performance. Instead of having a fixed percentage COLA or a CPI-lined COLA, a plan with a contingent COLA will change COLA within a range depending on the plan's performance. For example, a plan adopts a COLA of 3 percent when its funded ratio is 100 percent or above and 1 percent otherwise. In this case, if the inflation rate is below 1 percent, employees are protected from inflation; if the inflation rate is between 1 percent to 3 percent, the inflation risk is shared between employees and employers depending on the funded ratio; if the inflation rate is above 3 percent, the risk is borne by employees. Contingent COLAs can also be linked with investment performance, the retirees' age, or the length of retirement. According to a NASRA (2019) report, six states have adopted certain types of contingent COLAs in their state-level pension systems, including Louisiana SERS, Maryland SRPS, Massachusetts SERS and TRB, Nebraska RS, South Dakota RS, and Wisconsin RS.

Contingent contributions link the pre-retirement employee contribution rates with actuarially determined contributions (ADC), normal cost, investment performance, or funded ratio. When a plan has different investment, actuarial or longevity experiences, the required cost for funding the plan will change. If the employees' contributions are contingent on plan costs and performance, the increased costs are shared between employees and employers. On the other side, if plans experience investment gains and cost decreases, the gains are also shared with employees through the decrease in employees' contributions. Many states have set up variable employees' contributions (NASRA, 2019). Most of the variable contributions are done by the share of ADC (i.e. ADC equally shared between employers and employees). Some state systems, such as Montana PERS, Montana ERS, and North Dakota Teachers' Fund, establish employees' contribution rate to vary within a range depending on funding status or actuarial condition (NASRA, 2019).

Plans with DB and DC features can be done in two ways: (1) cash balance plan and (2) DB-DC hybrid plan. A cash balance (CB) is like a DC plan in the way that each employee has their individual retirement account, to which both employees and employers make contributions. What is unique about a CB plan is that employers guarantee at least a certain rate of investment return. This guaranteed rate (such as 5 percent) is lower than the expected rate of return. In this way, CB plans provide benefits with a fixed portion (contributions plus investment returns at the guaranteed rate) and a variable portion (investment returns higher than the guaranteed). DB-DC hybrid plans consist of two separate plans: a plan with a lower DB benefit and a supplemental DC component. Employees also receive benefits from two portions: fixed benefits based on a DB formula with a lower multiplier (such as 1 percent) and variable benefits based on accumulated amount in individual retirement accounts.

Studies on risk-sharing mechanisms are limited. Novy-Marx and Rauh (2014) estimate the impact of variable annuities (benefits) linked to investment performance using an option-pricing model and compare this approach with other reform options, such as increased employee contributions and introducing collective DC plans. Novy-Marx and Rauh's work lays out a valuable framework for understanding risk-sharing but does not use stochastic simulations and examines only one specific risk-sharing mechanism. Yin and Boyd (2017) analyzed the impact of risk-sharing in the Pennsylvania Public School Employees Retirement System using a stochastic simulation model.

In this research, we focus on contingent COLAs and contingent employee contributions as ways to share risks. We use stochastic simulation to examine how risk-sharing mechanisms can affect contribution costs and risks for employers, and the lifetime value of benefits and risks for employees.

3. Methods

We use a stochastic simulation model of pension finances with steady-state demographics to examine the impact of contingent COLA and contingent contribution policies on pension costs, contribution risks, and retirement benefits.

We construct and examine stylized COLA and contribution policies that can capture the core features of the risk-sharing mechanisms adopted by real-world pension plans. The model does not intend to closely reflect the policies and actuarial practices of specific plans.

3.1 Pension simulation model with steady state demographics

We developed a stochastic simulation model for the finances of a hypothetical plan with steady state demographics, meaning that the size and age distribution of the active and retiree populations remain constant over time, as elaborated upon below. The steady-state assumption significantly reduces the complexity of our calculations, while still allowing important insights into the impacts of different risk-sharing policies. Policy scenarios we examined only differ from each other in the risk-sharing mechanisms they adopt.

The demographics of the hypothetical pension plan are assumed to be in a steady state. If the plan uses a constant COLA and the plan policies do not change over time, the steady state can be defined as follows:

- The number of active members in each age by year-of-service group and the number of retirees in each age group stay constant over time.
- The relative distribution of salary for active members across age by year-of-service groups and the relative distribution of retirement benefit retirees across age groups do not change over time, while the level of salary and the level of retirement benefit in each group all grow at a pre-assumed rate, which is equal to the growth rate of the starting salaries of new employees.
- With the steady state demographics described above, the resulting total payroll, total benefit payment, total actuarial liability, and total normal cost all grow at the same pre-assumed rate every year.

Note that once contingent COLA policy is introduced, the total benefit and liability will no longer grow at the constant rate. Rather, the annual growth rate of total benefit and liability will depend on the actual COLA rate determined based the COLA rule and the previous year's conditioning variable (investment return or funded ratio).

The steady state described above is a function of the following elements:

1) Decrement tables (mortality, separation rates, retirement rates, etc.).
2) Salary growth during the working life of employees.
3) Growth rate of starting salaries of new employees.
4) Age distribution of new employees.
5) Benefit provisions (retirement eligibility, rules for final average salary, benefit factor, COLA, etc.).

Given the elements above, the modeled pension plan will eventually converge to the corresponding steady state in the long run. Table 2 summarizes the assumptions on these elements we used to construct the steady state in this paper.[2]

Table 2. Key model assumptions

Data and parameters determining the steady state demographics and salary structure	**Decrement tables**	RP-2014 mortality tables Termination rates and disability rates based on Arizona State Retirement System (SRS)
	Salary table	Based on salary table of Arizona SRS
	Annual growth in starting salary of new employees	1.5%
	Age distribution of new employees	Based on the age distribution of low year-of-service employees in Arizona SRS
	Benefit provisions	- Only service retirement benefit is modeled - Single retirement age of 60 - Benefit factor: 3.2% - Final average salary: 3 years with the highest salaries
Other important assumptions	**Range of age**	20-100
	Starting funded ratio	100%
	Valuation method	Entry Age Normal
	Asset-smoothing*	5 years
	Amortization*	15-year level dollar closed amortization
	Employee contribution rate	6% of salary
	Employer contribution rate	No negative contributions (withdrawals)

* Does not applied to the COLA policies based on the South Dakota Retirement System (SDRS) described below.

Table 3 summarizes the key plan characteristics in the steady state model assuming a constant COLA of 1.5 percent.

Table 3. Key plan characteristics in the steady state model (based on 1.5 percent constant COLA)

Average age of active members	42.7
Average year of service of active members	9.2
Average age of retires	76.0
Ratio of active members to retirees	1.14
Ratio of total liability to payroll	11.2
Total normal cost as percentage of payroll	12%

3.2 Risk-sharing mechanisms modeled

Using the steady-state pension simulation model described above, we simulate the following stylized risk-sharing mechanisms.

- Contingent COLA mechanisms. Three stylized contingent COLA policies are examined
  - COLAs are granted only when the actual investment returns are greater than the assumed return of the plan.
  - COLAs are granted only when plan funded ratio (based on market value of assets) is above a predetermined threshold.
  - Full COLAs are granted when plan funded ratio (based on market value of assets) is above a predetermined threshold and are reduced based on by how much the funded ratio is below that threshold.
- The risk-sharing mechanism in the unique plan design of the South Dakota Retirement System. The SDRS policy is quite unique in the public pension universe which features the following key elements:
  - Constant statutory employer and employee contribution rates under normal funding conditions.
  - A unique COLA rule: the COLA is determined such that the COLA, if assumed forever, can make the plan's actuarial liability equal to the value of plan assets.
  - Requiring "corrective actions" when the plan is severely underfunded, which may include adjustments of benefits and changes in contributions.

- Contingent employer contribution policy. We examine a stylized policy based on the "shared-risk" employee contribution policy of the Pennsylvania State Employee Retirement System, in which employee contribution rate may change based on investment returns. This policy does not change the total liability and benefit payments of the plan and only affect how the total cost is shared between employer and employees.

3.3 Valuing actuarial liability under contingent COLA policy

A single COLA is used in annual actuarial valuations done within the model. In practice, actuaries typically value plan liability with contingent COLA by using a single deterministic COLA rate that is "actuarial equivalent" to the variable future COLA.[3] In this paper, we value plan liabilities every year using the same deterministic COLA rate across all contingent COLA policies to make comparison across policies more straightforward.

For the sponsoring governments, contingent COLAs can potentially reduce pension costs and dampen contribution volatility. Under common contingent COLA arrangements, the liabilities for retirees tend to move in tandem with the corresponding plan assets, resulting in less changes in unfunded liability and therefore smaller swings in required contributions. For example, consider a contingent COLA based on investment returns in which a 2 percent COLA will be granted if the return to the plan assets is greater than 7.5 percent in the previous year and no COLA will be granted otherwise. The plan liability is valued using a 1.5 percent deterministic COLA in each year. Suppose the realized investment return is 5 percent in the current year and therefore no COLA is granted. An actuarial loss will be created due to the investment shortfall for the next valuation year and an amortization cost will be added to the employer contribution. However, the amortization cost will be partly offset by an actuarial gain created by the difference between 1.5 assumed percent COLA used in the valuation and the actual COLA granted, which is 0. Thus, the total increase in contribution caused by the investment shortfall will be lower under the contingent COLA policy compared to under a constant COLA policy. Note that the liabilities of active members are not affected by the variations in annual COLA, as they are always valued based on the single deterministic COLA rate assumed by the plan.

3.4 Evaluating the impact of risk-sharing policies

We use the pension simulation described above to investigate how risks are shared between employers and employees through various risk-sharing mechanisms.

- **Impact on employers.** Pension funds and their sponsoring governments are mainly concerned about how risk-sharing mechanisms would affect to total pension costs and to what extent contribution volatility can be dampened.
- **Impact on employees.** Plan members (active and retired) care about their benefit levels and to what extent the benefits are protected from inflation risk through COLA arrangements. In the case of risk-sharing employer contribution, plan members care about how much more employee contributions they will expect to make before retirement.

3.4.1 Investment return scenarios

The risk-sharing policies are simulated under the following investment return scenarios:

- **Deterministic asset-shock scenario.** This scenario incorporates a severe adverse shock to investment returns in the second simulation year followed by a short recovery period and then returns equal to the earnings assumption over the long run. It is assumed that there is a 24 percent investment loss in year 2 followed by a three-year recovery period with annual returns around 12 percent, after which returns would stay constant at 7.5 percent.
- **Stochastic scenario: assumption achieved.** This scenario assumes that the expected long-run compound return is equal to the assumed return of 7.5 percent, with a standard deviation of 12 percent throughout the 40-year simulation period (an arithmetic mean return of 8.22 percent is used to achieve this).

4. Contingent COLA

We first examine our baseline policy with a constant annual COLA along with three contingent COLA policies, which are summarized in Table 4.

Table 4. Summary of COLA policies

COLA policy	Single COLA rate used in valuation	How COLA is determined	Example Plans
Constant COLA: 1.5 percent	1.5 percent	Constant 1.5 percent	
COLA contingent on investment return	1.5 percent	• 2 percent if return >= 7.5 percent • 0 percent if return < 7.5 percent	Maryland MSRPS
COLA contingent on funded ratio: threshold	1.5 percent	• 2 percent if funded ratio >= 90 percent • 0 percent if funded ratio < 90 percent	Arizona SRS
COLA contingent on funded ratio: ramp	1.5 percent	2 percent reduced by 0.1 percent for every 1 percentage point funded ratio lower than 90 percent	Montana PERS

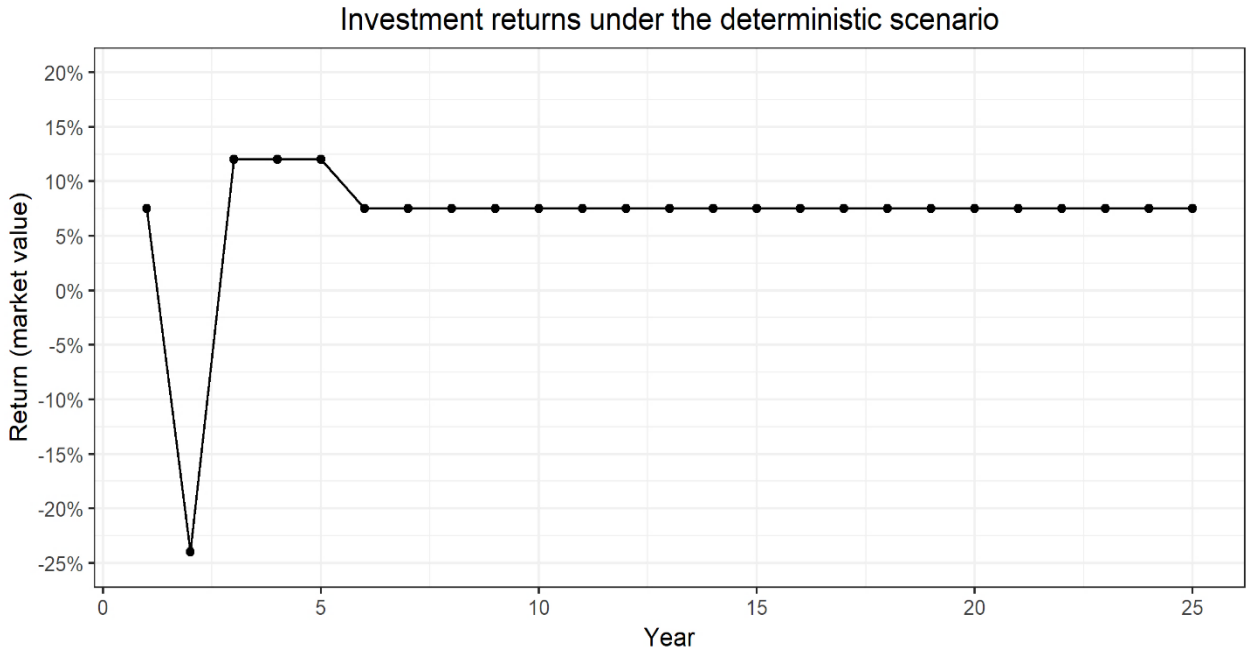
4.1 Deterministic asset-shock scenario

This section demonstrates how different contingent COLA policies would affect the pension costs and benefit level under a hypothetical asset-shock scenario similar to the Dodd-Frank stress-testing scenario.

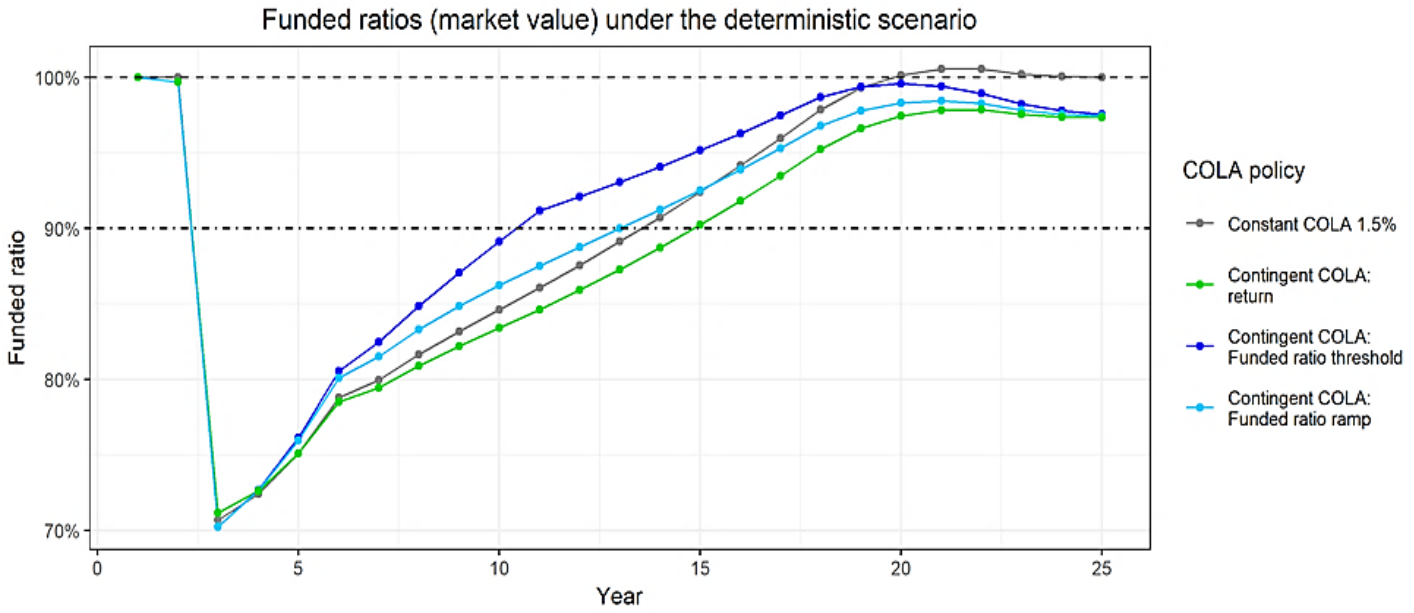
The analysis will focus on the first 25 years of the deterministic asset-shock scenario. Including longer periods in the model would not provide relevant information about the impact of COLA policies related to the asset shock during the initial years because: 1) the investment losses and gains created by the asset shock and the recovery period will have been fully recognized and amortized by year 25; second, the assumed constant return of 7.5 percent after the recovery period will not create any variation in COLA in longer term (in fact, the COLAs will remain constant under all policies after year 13).

Figure 6 shows the investment return, funded ratio, and the resulting COLA under different COLA policies. Under the investment-return-based contingent COLA policy, only the COLA in year 2 is affected. (Note that the full effect of the return-contingent COLA cannot be fully reflected in this asset-shock scenario because of the lack of variation in return after the asset-shock period.) Under the "contingent COLA: Funded ratio threshold" policy, there will be no benefit increase through year 3 to year 10 during which funded ratio is below 90 percent. Under the "Contingent COLA: Funded ratio: ramp" policy, COLA will drop to almost zero in year two and then gradually rise back to 2 percent in 10 years as funded ratio increases. The compound average annual COLA during this period is 1.1 percent.

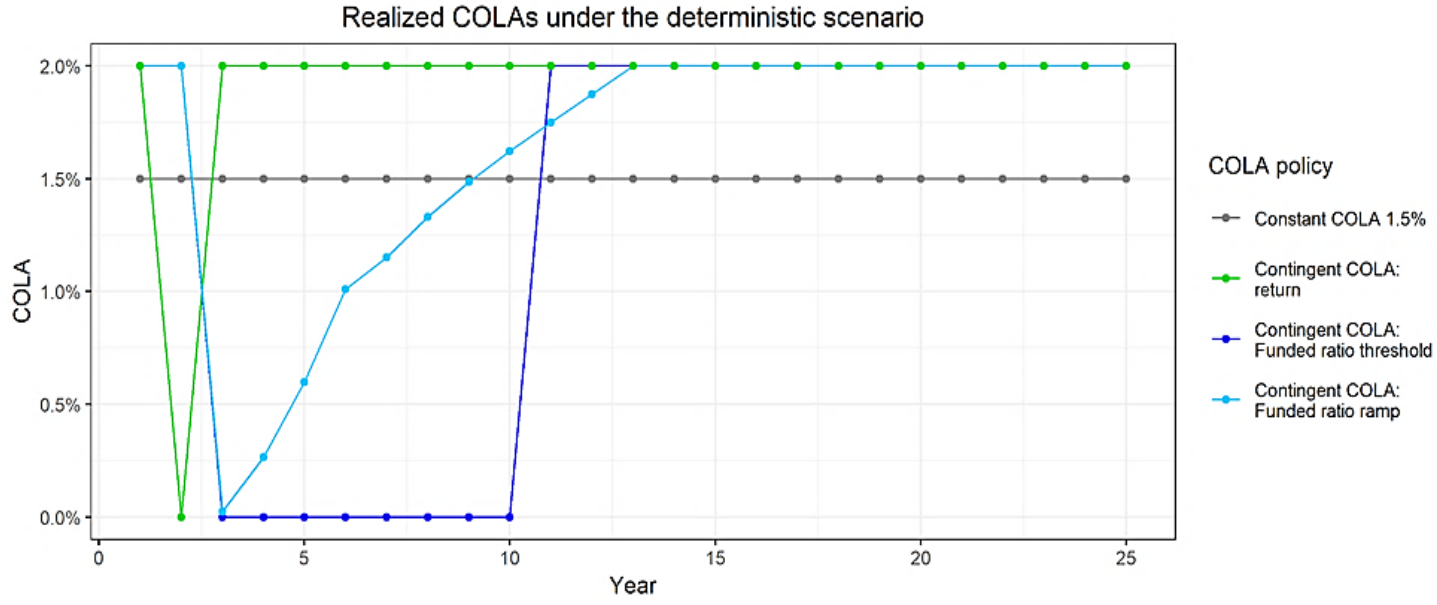
Figure 6. Investment returns, funded ratios and realized annual COLAs in the deterministic asset-shock scenario



(a)


Funded ratios (market value) under the deterministic scenario
Funded ratio
100%
90%
80%
70%
0
5
10
15
20
25
Year
COLA policy
Constant COLA 1.5%
Contingent COLA: return
Contingent COLA: Funded ratio threshold
Contingent COLA: Funded ratio ramp

(b)


Realized COLAs under the deterministic scenario
COLA
2.0%
1.5%
1.0%
0.5%
0.0%
0
5
10
15
20
25
Year
COLA policy
Constant COLA 1.5%
Contingent COLA: return
Contingent COLA: Funded ratio threshold
Contingent COLA: Funded ratio ramp

(c)

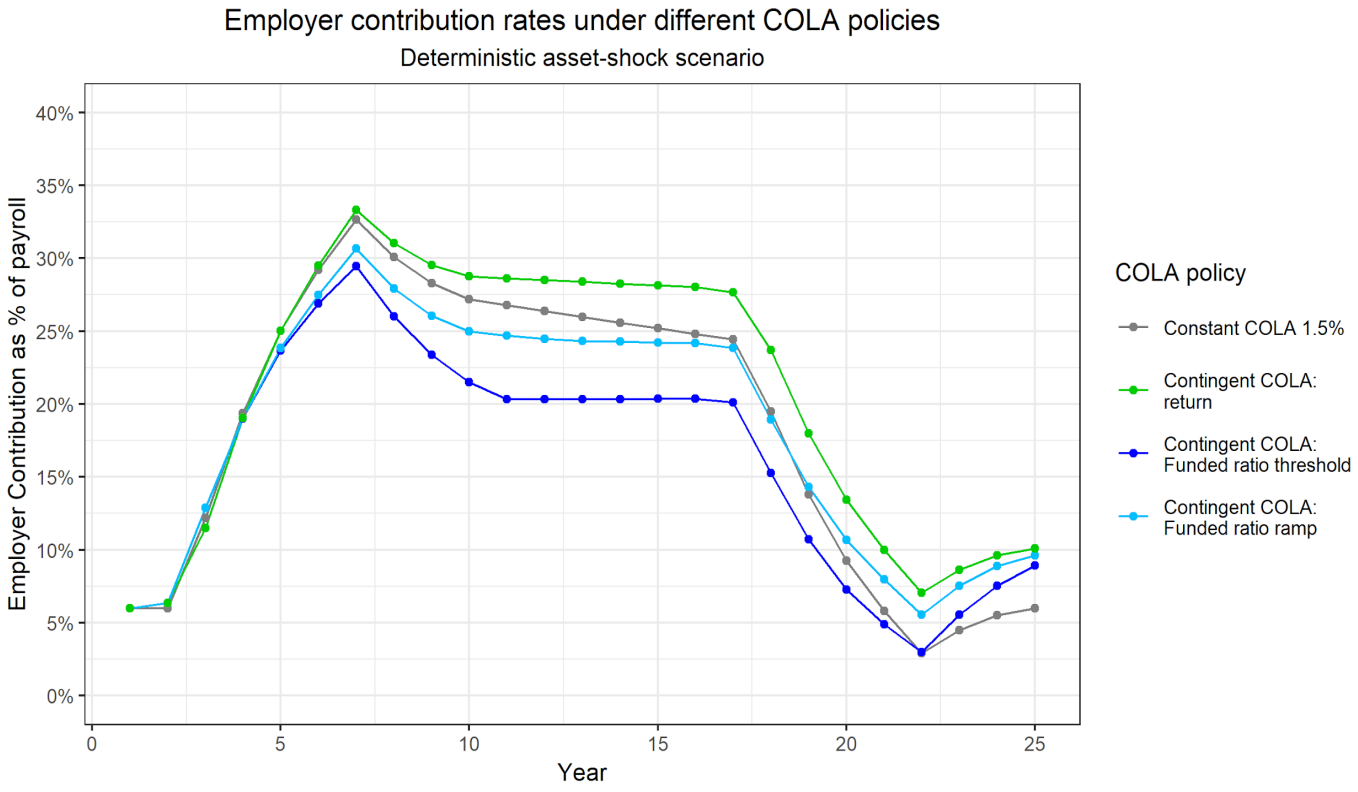
We then examine the cost-reducing and volatility-damping effects of the three contingent COLA policies under the deterministic asset-shock scenario. Figure 7 shows the employer contribution rates under these policies during the first 25 simulation years.

The "contingent COLA: threshold" has the strongest cost-reducing and volatility-damping effects as it provides zero COLA for 8 years after the asset shock. In year 11, the employer contribution rate is 20 percent under the "The contingent COLA: threshold", which is 7.5 percentage points lower than that under the 1.5 percent constant COLA policy. The present value of the employer contributions during the first 25 years under the "contingent COLA: threshold" policy is 13 percent lower than the amount under the 1.5 constant COLA.

The "contingent COLA: ramp" policy has a modest effect on employer contributions. Under this policy, the employer contribution rate is about 3 percentage points lower than that under the constant COLA policy around year 10. The present value of 25-year total employer contribution is only 2 percent lower than the amount under the 1.5 percent constant COLA.

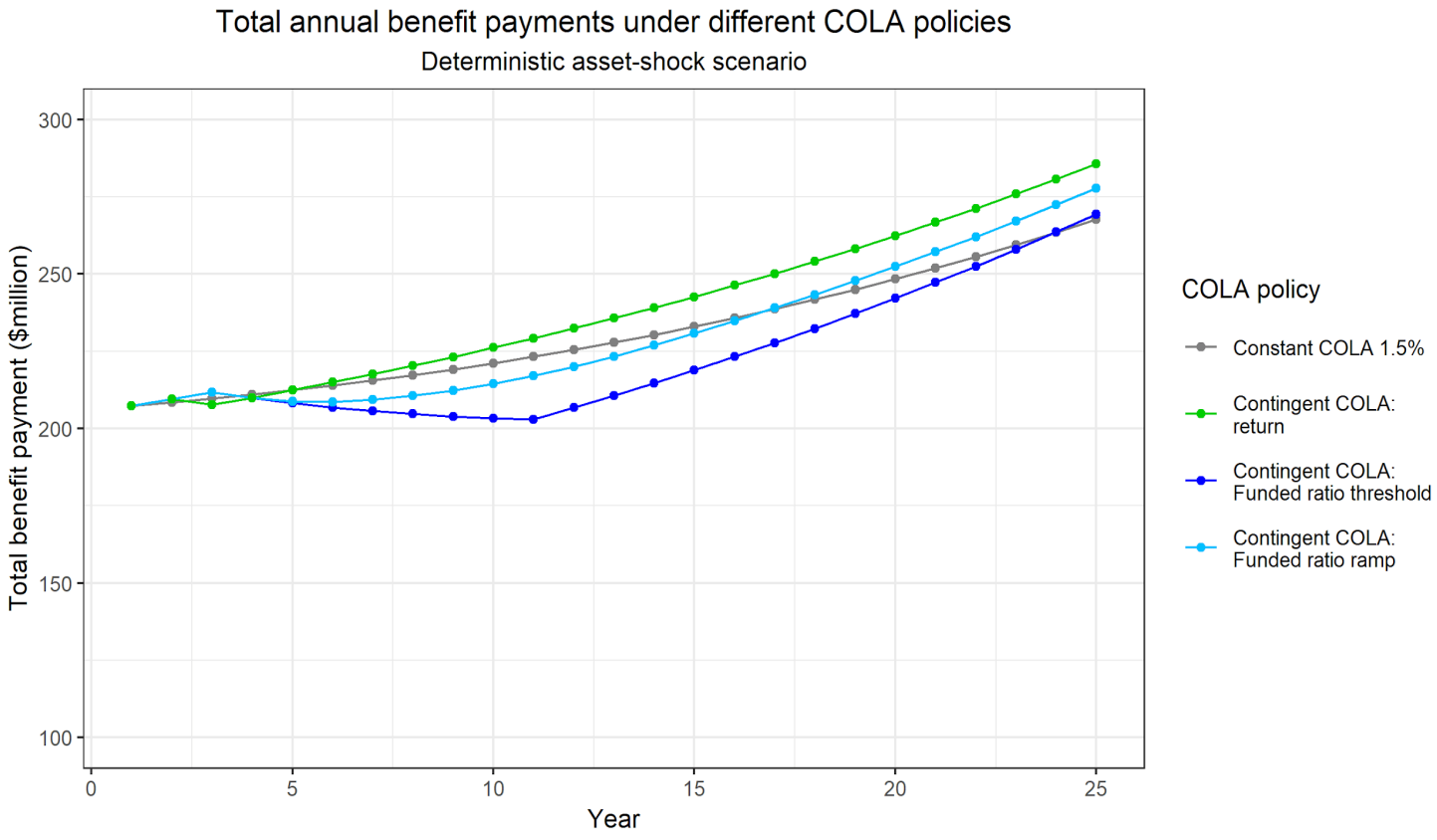
The COLA contingent upon investment return shows minimal effect under this asset-shock scenario because only one year's COLA is affected. In fact, the employer contribution under this COLA policy becomes even greater than that of the 1.5 percent constant COLA policy in later years because of the increasing amortization costs generated by the difference between the 1.5 percent COLA used in the valuation and the 2 percent COLAs realized in all years after the asset shock. Again, the effect of the return-based COLA policy cannot be fully manifested in this specific deterministic scenario.

Figure 7. The impact on employer contribution varies across COLA policies under the asset-shock scenario



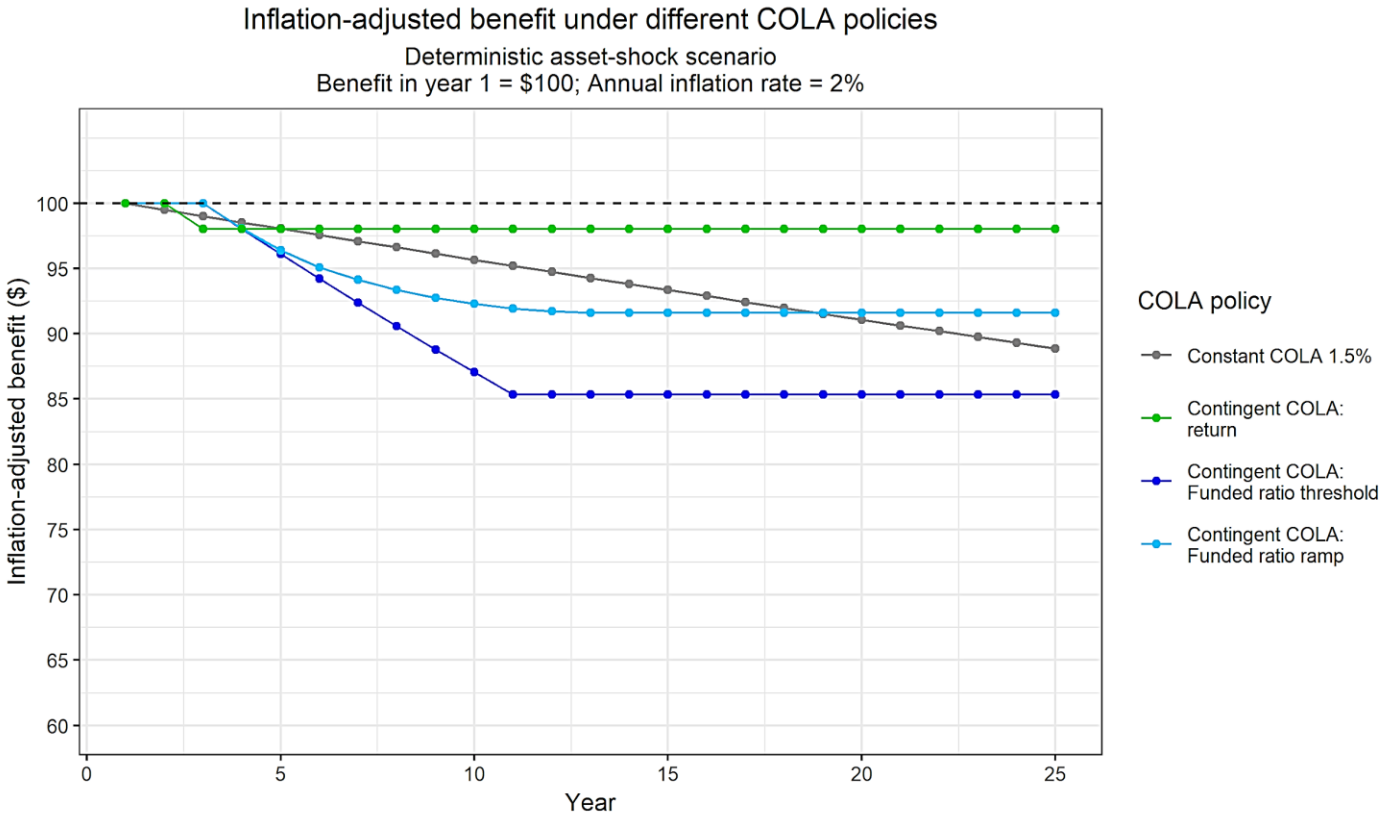
The contingent COLA policies' volatility-damping and cost-reducing effects come at the cost of reduced benefits for retirees. Figure 8 shows the annual total benefit payments under different COLA policies. The decreases in benefit payments are positively correlated with the cost-reducing effects of the contingent COLA policies shown above.

Figure 8. Reduction of benefits caused by the contingent COLA policies



The impact of contingent COLA policies on individual retirees can be better understood by looking at the stream of inflation-adjusted benefits that reflect the true purchasing power of the payments, for a single cohort. Figure 9 shows the inflation-adjusted benefits starting at $100 in year 1 over the 25-year period under different COLA policies. The purchasing power of the benefit declines by 15 percent under the "Contingent COLA on funded ratio: threshold" policy and by 9 percent under the "Contingent COLA on funded ratio: ramp" policy around year 15 of the asset-shock scenario.

Figure 9. The effects of contingent COLA policies on inflation-adjusted benefits for a single cohort are significant and can compound over time



We have demonstrated with the deterministic asset-shock scenario the risk-sharing mechanisms of different contingent COLA policies and illustrated how the additional cost caused by a one-time asset-shock is shared between employer and employees. The full effect of the contingent COLA can be only understood in stochastic simulation settings, which is the focus of the next section.

5. Stochastic scenario

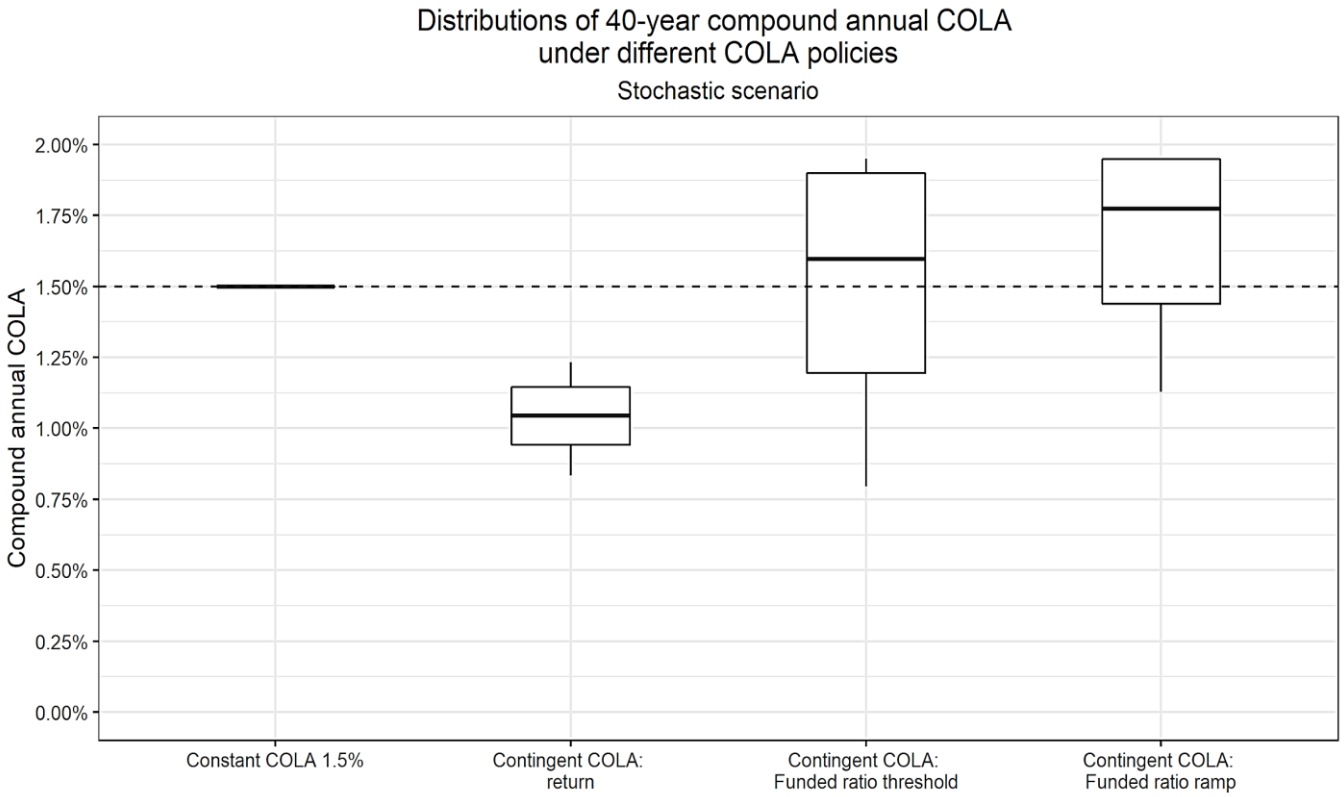
Figure 10 shows the distribution of 40-year compound annual COLA under different COLA policies. Under the "Contingent COLA: return" policy, the median COLA is close to 1 percent, which is the middle

point between the ceiling COLA (2 percent) and floor COLA (0 percent) in this policy, and distribution is very concentrated around the median compared to the other two contingent COLA policies.

The median COLAs under the two funded ratio-based COLA policies are both higher than the baseline of 1.5 percent. The higher median COLAs under these policies can be mostly attributed to two factors. First, as the plan starts with 100 percent funded ratio in year 1 and the expected long-term average return in this scenario is equal to the discount rate of the plan (7.5 percent), the funded ratio under these policies is more likely to stay above the threshold of 90 percent below which the COLA is reduced. Second, the model does not allow negative contributions (withdrawal from the fund) even when a large surplus exists, which pushes upward the distribution of funded ratio and in turn the distribution of compound annual COLA.

The distribution of the compound annual COLA under the "Contingent COLA: Funded ratio threshold" is more dispersed and has a longer lower tail compared to that of the "Contingent COLA: Funded ratio ramp". This is because the "Contingent COLA: Funded ratio threshold" policy, which grants either 2 percent COLA or no COLA depending on the funded ratio, makes the COLA more sensitive to investment performance. In contrast, the "Contingent COLA: Funded ratio ramp" policy, which phases COLA down from 2 percent to 0 when funded ratio falls below 90 percent, leads to higher median compound annual COLA (1.76 percent vs. 1.6 percent) and less variation across simulations.

Figure 10. Uncertainty in 40-year compound COLA under contingent COLA policies



We then examine how the variations in annual COLAs under these stylized contingent COLA policies translate into variations in **plan costs** and **contribution volatility**. Plan cost is measured by the present value of employer contributions over the 40-year simulation period, and contribution volatility is measured by the maximum increase in employer contribution as a percentage of payroll within a 5-year period during the 40 years.[4] Under each policy, we calculate these measures for each of the 1,000 simulations and construct their distributions. The summary statistics are presented in Table 5.

The low expected COLA under the "Contingent COLA: return" policy leads to the strongest cost-reducing effect among the three contingent COLA policies and the magnitude of cost-reduction under this policy is similar across all market conditions. Compared to the constant 1.5 percent COLA policy, the cost reduction under the return-based COLA policy is around 12 percent across all percentiles.

Compared to the return-based policy, the two funded-ratio-based contingent COLA policies generally provide less cost-reduction; however, their reductions are more significant in worse market conditions (higher percentiles in the cost distributions). The "Contingent COLA: Funded ratio threshold" policy provides 5 percent cost reduction in the median case and 13 percent cost reduction at the 90th percentile, while the "Contingent COLA: Funded ratio ramp" policy leads to a 4 percent cost increase in the median case, and an 8 percent cost reduction at the 90th percentile. Both funded-ratio-based policies lead to slightly higher cost relative to the baseline policy in better-than-average market conditions (lower tails of the cost distributions).

The right panel of Table 5 shows that the contribution-volatility-dampening effects, measured by the maximum increase in employer contribution rates within 5 years, are modest under all three contingent COLA policies (1 to 3 percentage points lower than under the baseline). The contribution-volatility-dampening effect under the "Contingent COLA: return" policy is slightly stronger because annual COLAs and the resulting changes in liability are more responsive to the investment performance under this policy.

Table 5. Impact of contingent COLA policies on pension costs and contribution volatility

	Present value of employer contribution Indexed to the median result (set to 100) for the baseline				Maximum increase in employer contribution rate in 5 years			
	Constant COLA 1.5% (Baseline)	Contingent COLA: return	Contingent COLA: funded ratio threshold	Contingent COLA: funded ratio ramp	Constant COLA 1.5% (Baseline)	Contingent COLA: return	Contingent COLA: funded ratio threshold	Contingent COLA: funded ratio ramp
Median relative to constant COLA	1.00	0.88	0.95	1.04	1.00	0.92	0.93	0.95
Percentiles								
90th	223	198	193	205	72%	69%	71%	70%
75th	165	146	148	160	45%	42%	43%	43%
Median	100	88	95	104	***32%***	***29%***	***29%***	***30%***
25th	48	41	51	56	22%	20%	20%	21%
10th	17	15	20	20	11%	8%	12%	13%

Note that the magnitudes of the cost-reducing effect and the volatility-dampening effect shown in Table 5 are relatively small compared to the overall variations of plan cost and contribution level, suggesting that these contingent COLA policies can only marginally mitigate the overall investment-related risk for employers. The effects can be more significant during periods with severe asset losses as demonstrated by the reduction of employer contribution rate by 3 to 7 percentage points in the deterministic asset-shock scenario. For the stochastic scenario, we compare the employer contribution rates under the contingent COLA policies with that under the constant COLA policy in each of the 40,000 simulation years (40 years x 1,000 simulations) and present the distributions in Table 6. The contribution reductions of 2 to 7 percent of payroll shown in the lower tails of the distributions may look attractive to sponsoring governments.

Table 6. Comparing employer contribution rates between constant COLA and contingent COLA policies in all simulation runs

	Difference in employer contribution rate between the contingent COLA policies and the baseline constant COLA policy (%)		
	Contingent COLA: return	Contingent COLA: funded ratio threshold	Contingent COLA: funded ratio ramp
Percentiles			
90th	0	1.8	2.6
75th	0	0	0.7
Median	0	0	0
25th	-3.7	-2.1	0
10th	-5.4	-6.7	-3.9

Note: The distributions are constructed based on the pooled 40,000 simulation years (1,000 simulations x 40 years).

Next, we examine the impact of contingent COLA on retirement benefits under the stochastic scenario. We focus on a single cohort of retirees who are at age 60 in year 1 and examine how contingent COLA policies affect their **level of benefit**, which is measured by the present value of lifetime benefits over 40 years, and **benefit volatility,** which is measured by the maximum decrease in inflation-adjusted retirement benefit in 5 years during the 40-year period. To make comparison easier, the present values of lifetime benefit are indexed to the median result under the baseline policy (set to 100). Under each COLA policy, we calculate the measures of benefit level and benefit volatility for each of the 1,000 simulations and construct the simulated distributions, which are presented in Table 7.

The left panel of Table 7 shows that the "Contingent COLA: return" policy generally leads to lower benefit compared to the two funded-ratio-based contingent COLA policies. The lifetime benefit under the return-based contingent COLA policy is almost always lower than the benefit under the baseline policy (see the second column of the left panel): even at the 90th percentile, the present value of lifetime benefit under the return-based contingent COLA policy is still 2 percent lower than the baseline benefit. In

comparison, the two funded-ratio-based contingent COLA policies create downside benefit risks similar to that under the return-based policy, while they can also lead to a chance greater than 50-percent that the lifetime benefit value is greater than that under the baseline (the fourth and fifth columns of the left panel).

The right panel of Table 7 shows that under the "Contingent COLA: return" policy annual benefits are more volatile, and retirees are generally more likely to experience large short-term benefit decreases compared to the two funded-ratio-based COLA policies. Under the return-based contingent COLA policy, annual benefit changes are determined by annual investment returns, which are highly volatile in the short term regardless of the long-term market conditions. Consequently, the short-term benefit volatility under the return-based contingent COLA policy can be large even when the long-term market performance and the plan funded status are good. This is demonstrated by the high maximum 5-year benefit decreases across all percentiles of the distribution under the return-based COLA policy (second column of the right panel). In comparison, the funded-ratio-based COLA policies are much less likely to lead to short-term benefit decreases when the long-term market condition is good and the resulting plan funded ratio is high, which is shown by the much lower maximum 5-year maximum benefit decreases at the 90th and 75th percentiles under these policies compared to the return-based COLA policy. At the 25th and 10th percentiles, the two funded-ratio-based COLA policies lead to slightly larger 5-year benefit decreases than the return-based COLA policy because COLAs under these policies will remain persistently low when bad market conditions result in persistent low funded ratio.

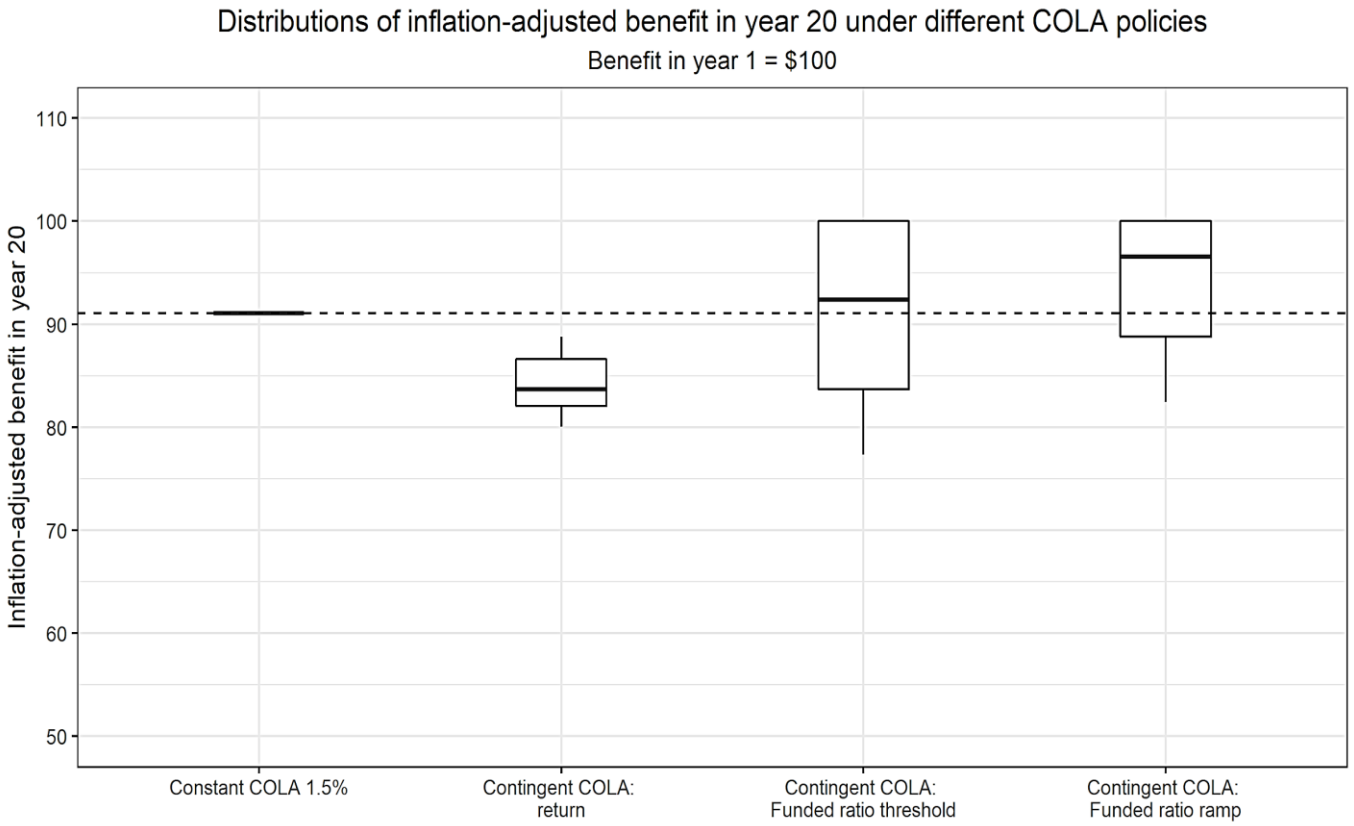
Table 7. Impact of contingent COLA policies on benefit level and benefit risk for a single cohort

	Present value of lifetime benefit for a single cohort indexed to the median result (set to 100) for the baseline				Maximum decrease in inflation-adjusted benefit in 5 years for a single cohort (Year-1 benefit = 100)			
	Constant COLA 1.5% (Baseline)	Contingent COLA: return	Contingent COLA: funded ratio threshold	Contingent COLA: funded ratio ramp	Constant COLA 1.5% (Baseline)	Contingent COLA: return	Contingent COLA: funded ratio threshold	Contingent COLA: funded ratio ramp
Median relative to constant COLA	1.00	0.95	1.01	1.04	1.00	3.08	3.38	1.89
Percentiles								
90th	100	98	106	106	-2.43	-6.09	0.00	0.00
75th	100	97	106	106	-2.43	-6.86	-1.96	-0.04
Median	***100***	***95***	***101***	***104***	***-2.43***	***-7.47***	***-8.21***	***-4.59***
25th	100	94	95	99	-2.43	-8.05	-9.43	-8.41
10th	100	93	91	95	-2.43	-8.88	-9.43	-9.12

To better illustrate the benefit volatility caused by the contingent COLA for individual retirees, we examined the distributions of the inflation-adjusted benefit in year 20 (age 80) (see Figure 11). For retirees who live from paycheck to paycheck during retirement, the level of annual benefit payments is a more relevant measure for their welfare associated with the pension benefit than the present value of total future benefit.

In both funded-ratio-based COLA policies, there is a 25 percent chance that the benefit payment in year 20 maintains the same purchasing power as in year 1. There is a 25 percent chance the inflation-adjusted benefit in year 20 will be below 85 percent of the year 1 value under the policy "COLA contingent on funded ratio: threshold", or below 89 percent of the year 1 value under the policy "COLA contingent on funded ratio: ramp".

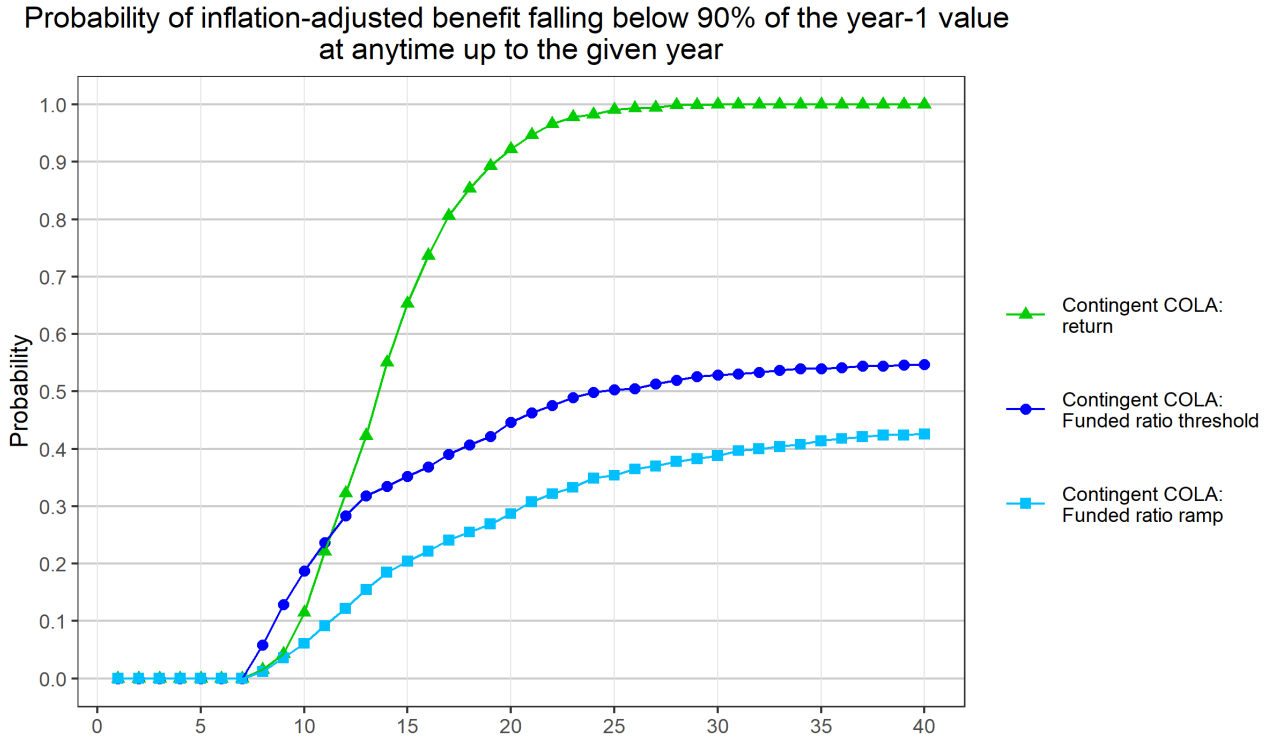
Figure 11. The impact of contingent COLA policies on the inflation-adjusted benefit in year 20



We also constructed a probability-based measure of low benefit level in real values, which is the probability of the inflation-adjusted benefit falling below 90 percent of the year 1 value at any time up to a given year (see Figure 12).

Retirees may face a substantial risk that the real value of their benefits will fall by 10 percent or more at some time during the retirement lifetime, especially under the return-based COLA policy. Although the return-based COLA policy results in relatively low variation in the present value of total benefit, retirees under this policy bears quite high risk of experiencing low benefit sometime during retirement. This suggests that benefit streams under the return-based COLA can be very volatile, which would have a negative welfare impact on retirees who are risk-averse.

Figure 12. The impact of contingent COLA policies on risk of low benefit for retirees



Note: With the constant 1.5% COLA, the inflation adjusted COLA will fall below 90% of the year-1 value in year 23.

6. COLA policy styled after South Dakota Retirement System

The South Dakota Retirement System (SDRS) adopted a contingent COLA policy that bases COLA on inflation and plan funded status as part of the policy changes in response to the impact caused by the Great Recession. In 2017, South Dakota approved a new change to the SDRS contingent COLA policy which, along with other funding arrangements of SDRS, aims to achieve budgetary certainty for the sponsoring governments, funding sufficiency for the plan, and retirement adequacy for retirees.

The current SDRS policy includes the following fundamental features[5]:

- Fixed, statutory member and employer contribution rates. Currently, both employee and employer contributions of SDRS are fixed at about 6 percent of payroll.
- Flexible benefits that changes based on economic conditions and the SDRS funded status. Contingent COLA is the most important component of the flexible benefit arrangement.
- Statutory funding measurement thresholds that guides when changes in benefits and/or contributions ("corrective actions" in SDRS terms) should be made.

The SDRS policy is quite unusual in the public pension universe and worth careful analysis for other public pension plans seeking risk-sharing policy options. We modeled a simplified and stylized version of the SDRS policy using the steady-state pension model. We focused on the SDRS COLA policy and modified the valuation assumptions and the contingent COLA parameters to facilitate comparison with other contingent COLA policies examined in the previous section. The key features of the SDRS-type policy we modeled is summarized below.

- Employer and employee contribution rates are both fixed at 6 percent except when funded ratio falls below a threshold and corrective actions are required (described below).
- Baseline COLA assumption: 1.5 percent
- Annual COLA is determined in two steps:
    - **Step 1:** A baseline funded ratio is calculated using the baseline COLA assumption of 1.5 percent (applied to all active members and retirees, same below). If the baseline funded ratio is equal or greater than 100 percent, a 2 percent COLA is granted.
    - **Step 2:** If the baseline funded ratio calculated in Step 1 is less than 100 percent, then next year's COLA is set to a value that, if assumed for all future years in the actuarial valuation, would result in a 100 percent funded ratio. However, the COLA cannot be less than 0.
- Corrective actions. If the plan funded ratio is still below 100 percent even assuming zero COLA for all future years in Step 2 above, "corrective actions" must be taken to mitigate the funding gap. In the original SDRS policy, the corrective action recommendations shall include "timing for any benefit changes, contribution changes or any other corrective action, or any combinations of actions to improve the funding conditions".[6] However, no pre-specified guidance is given regarding what type of actions should be taken. We examined two hypothetical corrective actions that require contribution increases.
    - **Slow repayment of UAAL.** An additional amount of contribution is made based on the UAAL calculated using the baseline 1.5 percent COLA and 15-year open level dollar amortization method every year until the condition for corrective action is not met anymore. It is assumed that the additional contribution is evenly split between employer and employees.
    - **Fast repayment of UAAL.** The same as above except that the additional contribution is calculated based on a shorter amortization period of 5 years instead of 15 years.

The main purpose of this analysis is to illustrate the general mechanism of the SDRS contingent COLA policy and how it compares to other types of contingent COLA policies. As the stylized SDRS policy we modeled differs from the actual SDRS policy in many ways, the model results and conclusions may not be applicable to the actual SDRS policy.[7]

6.1 Deterministic asset-shock scenario

We first show the results for the two SDRS-type policies under the deterministic asset-shock scenario and compare them with the baseline constant COLA policy and the "Contingent COLA: Funded ratio ramp" policy. To ensure comparability, the funded ratios under the SDRS-type policies are calculated based on the baseline COLA of 1.5 percent as in other COLA policies (These are the baseline funded ratios used in the first step of COLA determination under SDRS-type policies).

Figure 13 shows the paths for funded ratios of these policies under the asset-shock scenario and the resulting annual COLAs. The large asset shock causes the funded ratios to drop to about 70 percent in year 3 and triggers corrective actions for the SDRS-type policies, and COLA drops to the floor level of zero in all three contingent COLA policies. After that, the paths of annual COLA of these three policies diverge greatly over time. As COLAs are tied to the plan funded status in all three policies, the divergence is largely attributable to the difference in their funding policies governing how the funding gap caused by the asset shock is repaid.

Under the "Contingent COLA: Funded ratio ramp" policy, the amortization rule aims to bring the plan back to full funding based on the baseline 1.5 percent COLA assumption, which is achieved in 20 years. The full COLA of 2 percent has been granted since the funded ratio rises above the threshold of 90 percent in year 13.

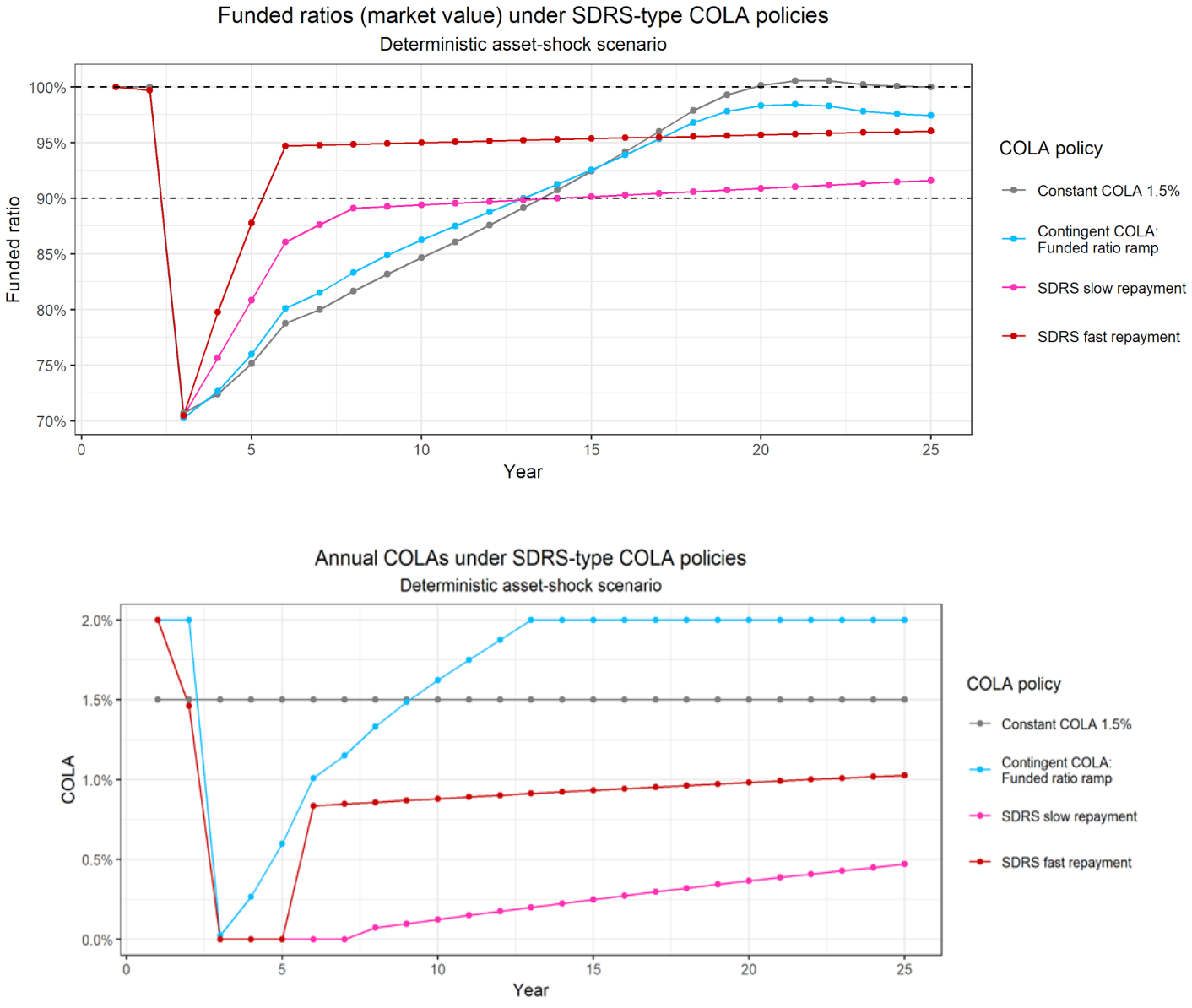
Under the stylized SDRS-type policies, COLAs are essentially determined by how the market value of plan assets compares to actuarial liability calculated using the 1.5 percent baseline COLA (step 1 in the COLA determination process). COLA decreases to 0 when the market value of assets falls to the actuarial liability calculated using the ***floor COLA of 0 percent,*** which is about 86 percent of the liability calculated with 1.5 percent COLA. From this perspective, the complex COLA determination process of SDRS is quite similar to a simple contingent COLA policy that determines COLA using a "funded ratio ramp".[8] Under the hypothetical SDRS policies we modeled, it is assumed that additional contributions are made only when the plan funded status is in the "corrective action" territory, that is, when the market value of plan assets is below the actuarial liability calculated using the ***floor COLA of 0 percent***; once the value of plan assets is lifted above the "corrective action" territory, the funded ratio calculated with zero future COLA (corresponding to the official funded ratio in the original SDRS) will become 100 percent and it is assumed that the plan will stop making contributions additional to the 6 percent statutory level. As investment returns in the asset-shock scenario will remain equal to the plan earnings assumption of 7.5 percent after year 5 (meaning no investment gains), there is little force driving the plan assets further up relative to the actuarial liability with 1.5 percent baseline COLA, resulting in stagnant COLA levels during the rest of the simulation period.[9]

Under the "fast repayment" corrective action policy, the "corrective action", along with the investment gains in the recovery period, drives the 1.5-percent-COLA-based funded ratio up to 95 percent, which corresponds to 0.9 percent COLA, before the plan stops making the "corrective action" contributions. By comparison, under the "slow repayment" corrective action policy, the 1.5-percent-COLA-based funded

ratio is lifted to 88 percent, corresponding to a COLA rate less than 1 percent. The difference in annual COLA between these two policies then stay stable after year 8.

The results of the deterministic scenario demonstrate that, after a severe asset shock, a crucial determinant of the future COLAs under the SDRS-type policies is **how fast and by how much** the funding policy can bring the funded status above the "corrective action" territory (about 86 percent funded ratio calculated using the 1.5 percent baseline COLA).

Figure 13. Funded ratios and realized annual COLAs under the SDRS-type policies in the deterministic asset-shock scenario

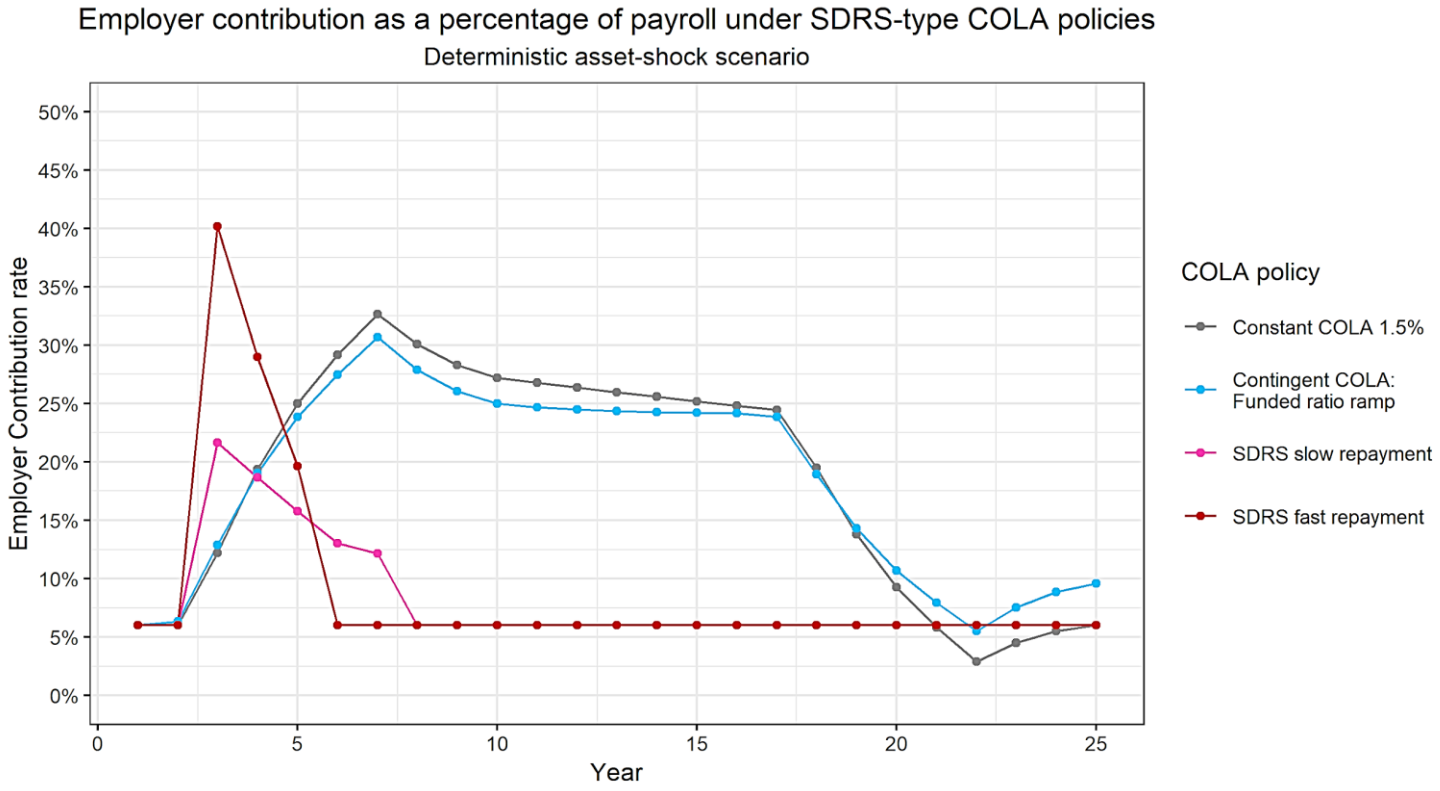


The SDRS-type policies lead to very different patterns of employer contributions due to the assumed corrective action policies compared with the simpler contingent COLA policies, as illustrated in Figure 14.

Under the SDRS-type policies, employer contribution rates spike right after the asset shock but quickly falls back to the statutory rate after the corrective action ends. Besides the corrective actions, another factor contributing to the hike in employer contribution rates is that SDRS policies do not use asset smoothing and therefore investment losses are recognized immediately and incorporated into the calculation of additional contributions.

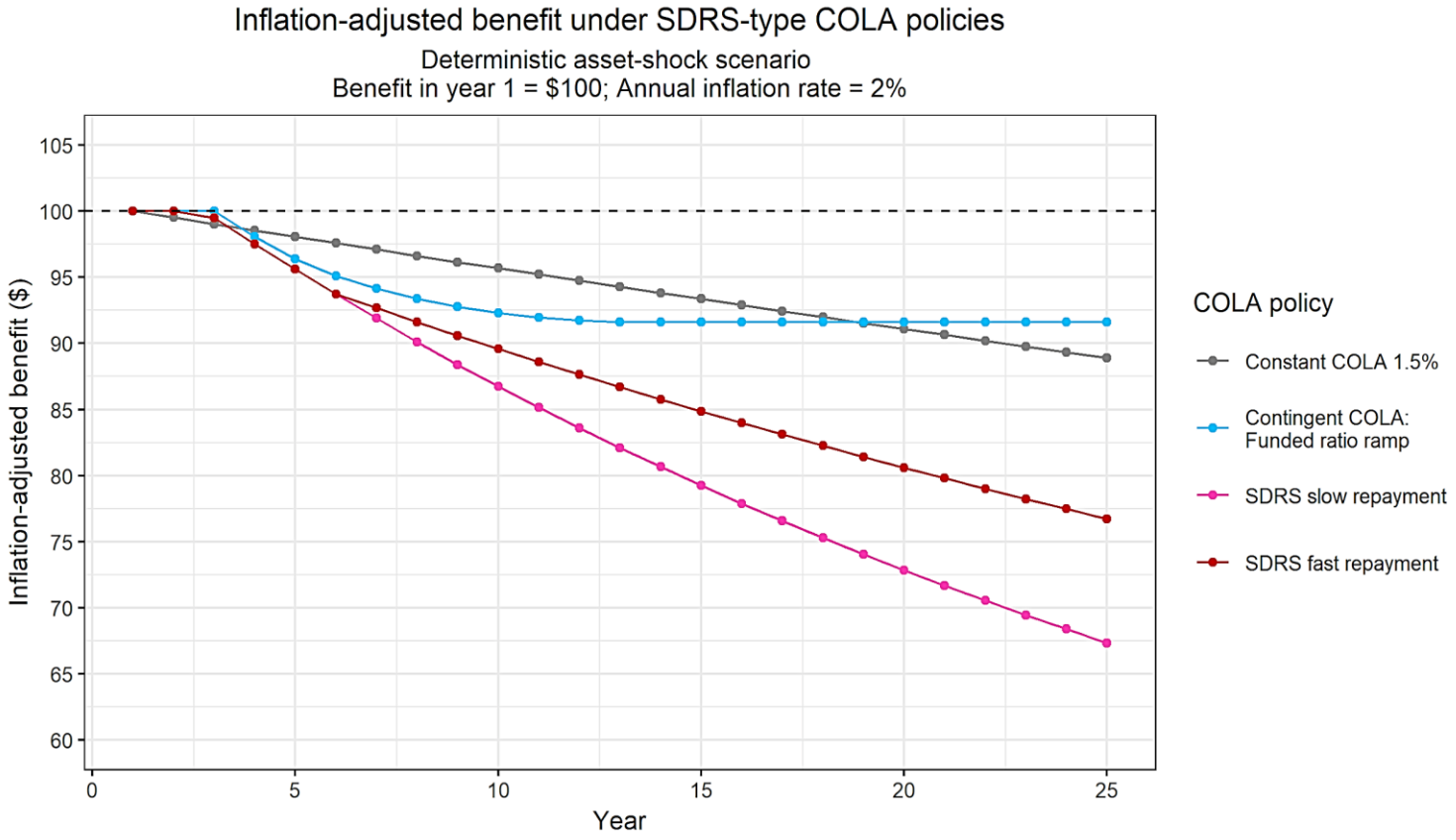
Note that it is assumed that the corrective action contributions are equally shared by the employer and employees. This suggests that the employee contribution rates would increase by the same amount after the asset shock (15 percent to 35 percent of payroll), which would not be possible in the real-world. If all the burden of corrective action contributions is shifted to the employer, the employer contribution rates will become prohibitively high after the asset shock (30 percent under the "slow repayment" policy and 75 percent under the "fast repayment policy").

Figure 14. The impact of the SDRS-type policies on employer contribution under the asset-shock scenario



The extended periods with low annual COLAs under the SDRS-type policies cause substantial decreases in inflation-adjusted benefits. (See Figure 15, which shows inflation-adjusted benefits for a single cohort.) The decrease in benefits would be less substantial if the plan took more aggressive corrective actions, including more consistent repayment of the UAAL and benefit cuts, to bring the funded ratio up, which would protect the current retirees at the expense of putting more contribution burden on current active members and taxpayers and/or reducing their future benefit.

Figure 15. The effects of SDRS-type policies on inflation-adjusted benefits are significant



6.2 Stochastic scenario

Figure 16 shows that the median compound annual COLAs under the two SDRS-type policies are slightly higher than that under the baseline COLA of 1.5 percent. Due to the SDRS-type funding mechanism described above, the "slow repayment of UAAL" corrective action policy is more likely to lead to lower compound annual COLA, which is shown in the longer lower tail in its distribution. There is a 25 percent chance that the compound annual COLA is below 1 percent under the "slow repayment of UAAL" corrective action policy. The "fast repayment of UAAL" policy has significantly less variation in compound annual COLA across simulations.

Figure 16. Uncertainty in 40-year compound COLA under SDRS-like policies

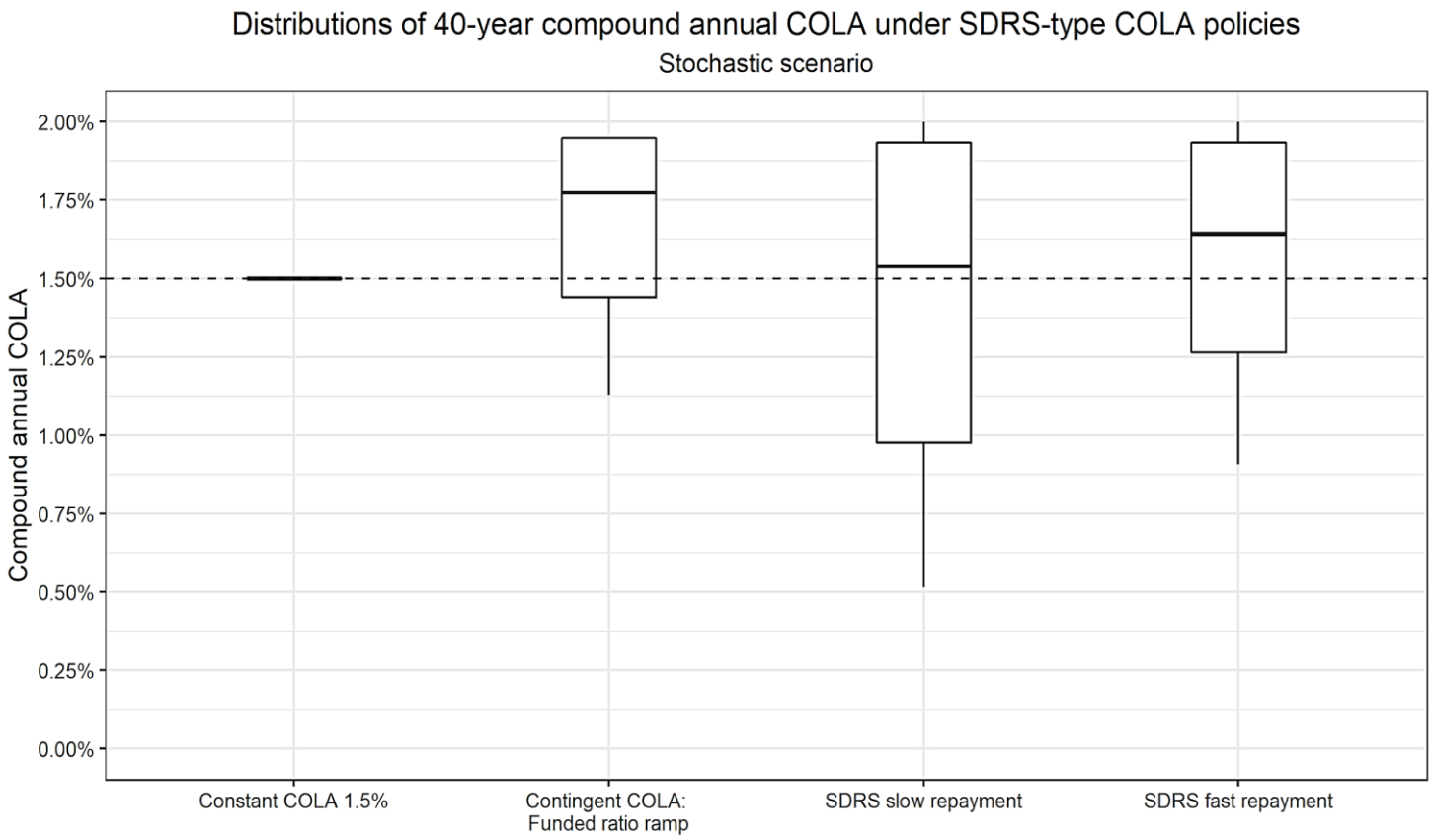


Table 8 shows the impact of the SDRS-type policies on **plan cost** and **contribution volatility.** The plan costs under the two SDRS-type policies are greatly lower than that under the constant COLA policy and the funded-ratio-based contingent COLA policy at the median and upper tail of the distribution (corresponding to normal and bad market conditions). The lower costs can be partly attributed to the assumption that the "corrective action" contributions are equally shared between the employer and employees.[10] If the employee portion of the corrective action contribution is added to the cost measure, the median costs will increase by 20 percent under the "slow repayment of UAAL" policy (78.5 vs. 66) and by 27 percent under the "fast repayment of UAAL" policy (91.4 vs 72). The higher costs under the SDRS-type policies at the lower tail of the distribution (corresponding to good market conditions) is due to the fixed employer contribution rate that does not drop to zero as does under other policies.

Similarly, the SDRS-type policies greatly reduce the risk of sharp increases in employer contribution rates largely due to the risk-sharing employee contributions. If the employee portions of corrective action contributions are taken into account, the maximum 5-year increase in employer contribution in the median cases under the SDRS-type policies will be almost doubled (13 vs. 23 percentage points; 23 vs. 46 percentage points).

Table 8. Impact of SDRS-like policies on pension costs and contribution volatility

	Present value of employer contribution Indexed to the median result (set to 100) for the baseline				Maximum increase in employer contribution rate in 5 years			
	Constant COLA 1.5% (Baseline)	Contingent COLA: funded ratio ramp	SDRS-like: slow repayment	SDRS-like: fast repayment	Constant COLA 1.5% (Baseline)	Contingent COLA: funded ratio ramp	SDRS-like: slow repayment	SDRS-like: fast repayment
Median relative to constant COLA	1.00	1.04	0.66	0.72	1.00	0.95	0.36	0.72
Percentiles								
90th	223	205	112	128	72%	70%	19%	36%
75th	165	160	89	101	45%	43%	16%	30%
Median	100	104	66	72	***32%***	***30%***	***12%***	***23%***
25th	48	56	53	53	22%	21%	0%	0%
10th	17	20	53	53	11%	13%	0%	0%

We then compare the employer contribution rates under the SDRS-type policies with that under the constant COLA policy in each of the 40,000 simulation years (40 years x 1,000 simulations) and present the distributions in Table 9.

The fixed statutory employer contribution rate under the SDRS-type policy does not drop even in scenarios with very good returns (represented by the higher percentiles), in which the employer contribution rate in the constant COLA policy, which uses regular funding method, may drop to zero due to the large surplus.

The employer contribution rates under the SDRS-type policies can be well below other policies (see the lower percentiles) as it is assumed that the SDRS-policies would stop paying the "corrective action" contributions once the 1.5-percent-COLA based funded ratio rises above the "corrective action" threshold, which is about 86 percent, while the baseline plan is still paying large amortization costs as the funded ratio is still far below 100 percent. This situation is illustrated by the contribution rates in year 7-17 of the deterministic asset-shock scenario (see Figure 14).

Table 9. Comparing employer contribution rates between constant COLA and SDRS-like policies in all simulation runs

	Difference in employer contribution rate between contingent COLA policies and the baseline constant COLA policy (%)		
Percentiles	Contingent COLA: funded ratio threshold	SDRS-type: slow repayment	SDRS-type: fast repayment
90th	2.6	6.0	6.0
75th	0.7	6.0	6.0
Median	0	2.4	4.0
25th	0	-14.3	-13.4
10th	-3.9	-30.4	-32.0

Note: The distributions are constructed based on the pooled 40,000 simulation years (1,000 simulations x 40 years).

We then examine the impact of the SDRS-type policies on **benefit level** and **benefit volatility**. The left panel of Table 10 shows that the median present values of benefit under the SDRS-type policies are almost the same as that under the constant COLA policy.[11] SDRS-type policies lead to lower present values of benefits in scenarios with bad returns (see the lower percentiles). The right panel of **Table 8** shows that the SDRS-type policies tend to cause slightly larger decreases in inflation-adjusted benefits in 5-year period than the "Contingent COLA: Funded ratio ramp" policy. The maximum decreases of benefit in 5-years under the two SDRS-type policies are like those of the "Contingent COLA: Funded ratio threshold" policy.

Table 10. Impact of contingent COLA policies on benefit level and benefit risk

	Present value of lifetime benefit for a single cohort Indexed to the median result (set to 100) for the baseline				Maximum decrease in inflation-adjusted benefit in 5 years for a single cohort (Year-1 benefit = 100)			
	Constant COLA 1.5% (Baseline)	Contingent COLA: funded ratio ramp	SDRS-type: slow repayment	SDRS-type: fast repayment	Constant COLA 1.5% (Baseline)	Contingent COLA: funded ratio ramp	SDRS-type: slow repayment	SDRS-type: fast repayment
Median relative to constant COLA	1.00	1.04	0.99	1.00	1.00	1.89	3.38	3.05
Percentiles								
90th	100	106	106	106	-2.43	0.00	0.00	0.00
75th	100	106	105	105	-2.43	-0.04	-2.43	-2.39
Median	***100***	***104***	***99***	***100***	***-2.43***	***-4.59***	***-8.21***	***-7.41***
25th	100	99	93	95	-2.43	-8.41	-9.04	-8.69
10th	100	95	89	92	-2.43	-9.12	-9.30	-9.17

The higher benefit risk under the SDRS-type policies can also be seen in the distribution of real benefit in year 20 (see Figure 17). Again, the benefit risk is greatly affected by the assumption on the "corrective action". The downside benefit risk would be lower if more aggressive corrective action policy.

Figure 17. The impact of SDRS-like policies on the inflation-adjusted benefit in year 20

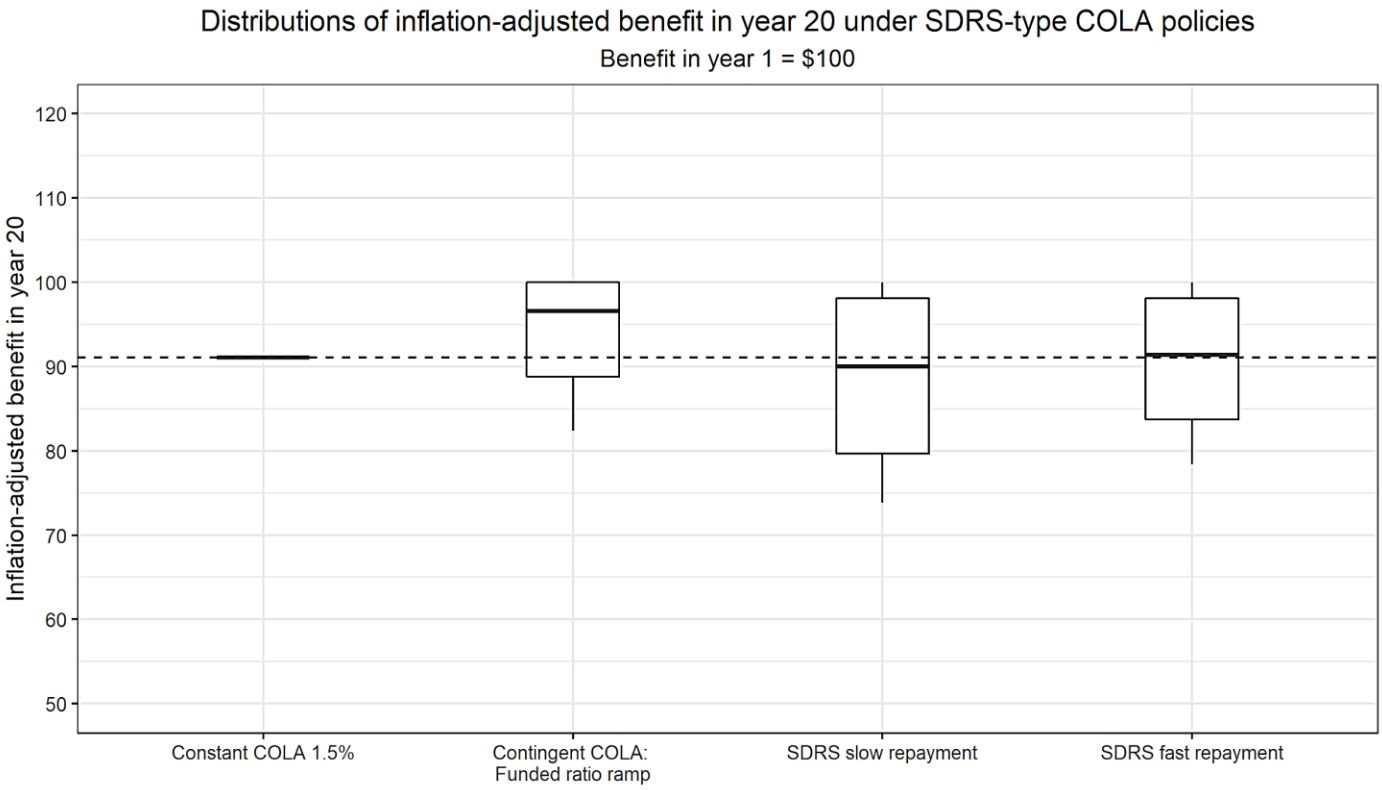
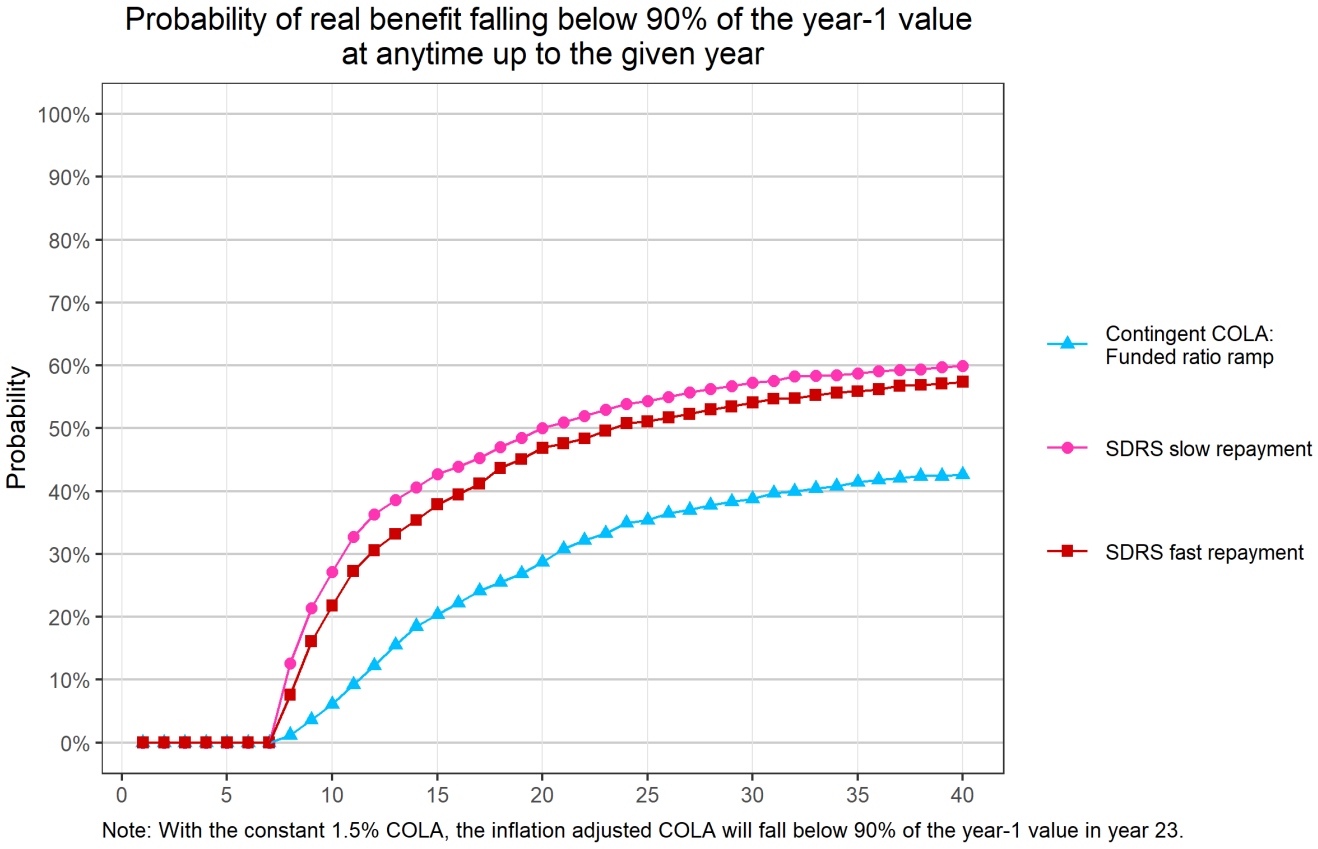


Figure 18 shows the probability-based measure of benefit risk: the probability of inflation-adjusted benefit falling below 90 percent of the value in the first year of retirement. The risk measures under the two SDRS-type policies are much higher than the measure under the "Contingent COLA: Funded ratio ramp" policy.

Figure 18. The impact of SDRS-like policies on risk of low benefit for retirees



Note: With the constant 1.5% COLA, the inflation adjusted COLA will fall below 90% of the year-1 value in year 23.

7. Contingent employee contribution rate

We analyzed a contingent employee contribution policy like the "shared-risk member contribution" policy of the Pennsylvania Public School Employees' Retirement System (PSERS). The policy we modeled is summarized below.

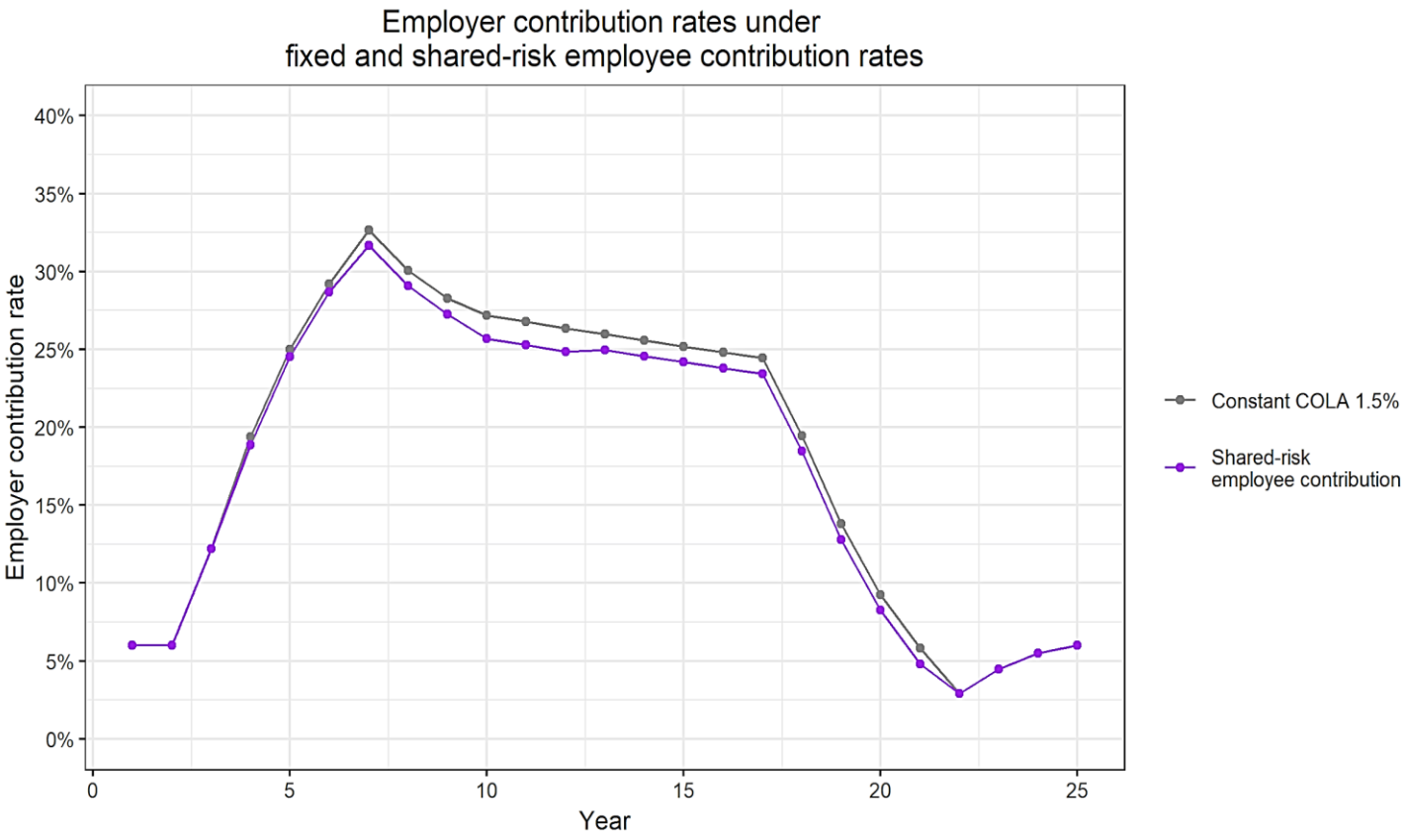
- The base rate of employee contribution is 6 percent of payroll.
- Every three years the fund compares prior investment performance to assumed performance.
- If the investment rate of return during the prior ten-year period is 1.0 percent or more above the assumed rate of return, the member contribution rate will decrease by 0.5 percent.

- If the investment rate of return during the prior ten-year period is 1.0 percent or more below the assumed rate of return, the member contribution rate will increase by 0.5 percent.
- The member contribution cannot fall 2 percentage points below the base rate and cannot be raised more than 2 percentage points above the base rate.
- If the retirement system is fully funded and the shared-risk employee contribution rate is greater than the base rate at the time of the comparison, the member contribution rate reverts to the base rate.

Under the deterministic asset shock scenario, the shared-risk employee contribution rate reaches its maximum of 2 percent around year 10, lowering the employer contribution rate by the same amount.

As shown in Figure 19, the impact of the contingent employee policy in the asset shock scenarios looks relatively small. This is largely because the PSERS shared-risk employee contribution policy 1) only allows for slow changes in employee contribution rates (contingent on 10-year rolling compound return; updated every 3 years) and 2) the 2-percentage point cap on the deviation from the base employee contribution rate.

Figure 19. The impact of contingent employee contribution policy on employer contribution under the asset-shock scenario



In Table 11, we compare the present value of employer contributions and the present value of employee contributions under the baseline constant COLA policy and the contingent employee contribution policy.

The results show that the contingent employee contribution policy would shift a small portion of the total plan cost from employees to the employer in average and good market conditions (corresponding to median and upper tail of the distribution). The median present value of employer contribution under the contingent employee contribution policies is 1 percent higher than that in the baseline policy, while the median present value of employee cost is reduced by about 8 percent. The shift of costs toward the employer in the median case can be largely attributed to the provision that reverts the employee contribution rate to 6 percent if the plan is fully funded, even if investment returns fell short.

In simulations with bad investment returns in which the funded status is poor and as a result the provision reverting employee contribution rate is less likely to apply, the plan costs are slightly shifted toward the employees. The present value of employer contribution at the 90th percentile is about 3.2 percent lower than that in the baseline policy, while the 90th percentile of the present value of employee contribution is about 13 percent higher than that in the baseline policy.

Table 11. Impact of contingent employee contribution policy on pension costs and contribution volatility

	Present value of employer contribution		Present value of employee contribution	
	Constant COLA 1.5%	Shared-risk employee contribution	Constant COLA 1.5%	Shared-risk employee contribution
Percentiles				
90th	223	216	100	113
75th	165	162	100	105
Median	100	101	100	92
25th	48	51	100	83
10th	17	18	100	80

Note: The present values of employer and employee contributions are indexed to their respective median results for the baseline constant-COLA policy.

8. Summary of results

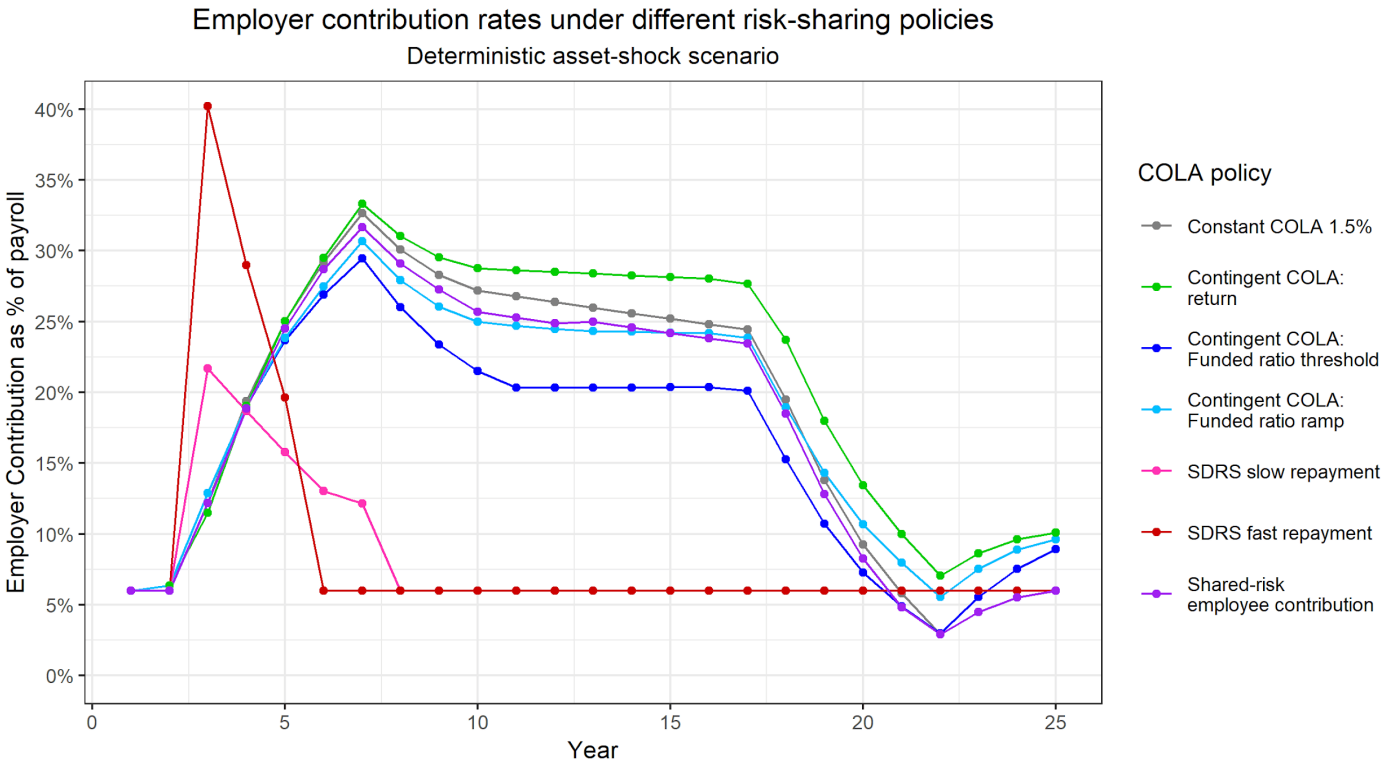
In previous sections we examined different kinds of risk sharing policies separately: first, contingent COLAs, then COLA policies styled after the South Dakota Retirement System policies, and then a contingent employee contribution policy. In this section we compare important results across all six policies we examined.

8.1 A deterministic asset-shock scenario

Our asset shock scenario has a 24 percent investment loss in year 2 followed by a three-year recovery with annual returns around 12 percent, after which returns are a constant 7.5 percent. Figure 20 shows the impact on employer contributions.

None of the policies prevented a sharp spike in employer contributions. The two SDRS-like policies could not achieve full funding even with zero COLAs and so the corrective action requirement was triggered. Under our assumptions (which are not intended to predict what South Dakota might do in such a situation) this caused both employer contributions and employee contributions (not shown) to rise sharply. Among other policies, the two with a funded-ratio trigger caused the largest contribution reduction. The "Contingent COLA: Funded ratio threshold" policy had the strongest cost-reducing and volatility-damping effects because the funded ratio was driven down so far below the 90 percent threshold that it provided zero COLA for 8 years after the asset shock. The "ramp" policy had a far more modest effect on employer contributions. The COLA contingent upon annual investments return showed minimal effect under this asset-shock scenario because only one year's COLA is affected. However, a return-based COLA policy can have significant effects in stochastic scenarios, where investment returns vary considerably from year to year.

Figure 20. Employer contribution rates under asset shock scenario



8.2 Stochastic scenarios

Table 12 summarizes important results from our stochastic analysis. The rows show the baseline policy (1.5 percent COLA every year - in gray) and the six risk-sharing policies we examined. Notes at the bottom of the table describe each policy briefly.

The columns are divided into two main blocks that summarize the impacts on employers and members, respectively. (For members, we focus on the impact over the lifetime for a single cohort, to avoid mixing cohorts. That issue does not arise with employers because the employer lives forever in our model.) The blocks show, respectively, the cost of employer contributions and their short-term volatility, and the lifetime value of member benefits and the short-term benefit volatility.

- Employer contributions:
    - *Cost to the employer:* The two columns in this subgroup show the present value of employer contributions indexed to present value contribution cost of the baseline policy in the median simulation. The left column shows the present value at the median simulation, and the right column shows the value at the 90th percentile (a more-expensive scenario for the employer, a good scenario for members).
    - *Short-term volatility of employer contributions:* The two columns in this subgroup show the maximum increase in contributions that the employer faced in any 5-year period in our simulations, as a percentage of payroll, in the median simulation run and at the 90th percentile.
- Member benefits for a single cohort:
    - *Lifetime value of benefits:* The two columns in this subgroup show the present value of benefits over a single cohort's lifetime indexed to the present value for the baseline policy in the median simulation. The left column shows the present value at the median simulation, and the right column shows the value at the 10th percentile (a bad scenario for the member, a less-expensive scenario for the employer).
    - *Short-term volatility of member benefits:* The two columns show the maximum decrease in benefits that the cohort faced in any 5-year period of our simulations, as a percentage of payroll, in the median simulation run and at the 10th percentile.

Table 12. Summary of key results

Comparison of shared-risk policies analyzed in this paper

Selected results from stochastic simulations

	Impact on employer contributions				Impact on benefits for a single cohort			
	Present value of employer contributions		Maximum increase as % of payroll, any 5-year period		Present value of lifetime benefit		Maximum % decrease in inflation-adjusted benefit, any 5-year period	
Policy	Median	90th percentile	Median	90th percentile	Median	10th percentile	Median	10th percentile
(a) Constant COLA 1.5% (baseline)	100	223	32%	72%	100	100	(2.4)	(2.4)
Contingent COLA policies								
(b) Contingent COLA: return	88	198	29%	69%	95	93	(7.5)	(8.9)
(c) Contingent COLA: funded ratio threshold	95	193	29%	71%	101	91	(8.2)	(9.4)
(d) Contingent COLA: funded ratio ramp	104	205	30%	70%	104	95	(4.6)	(9.1)
Policies styled after South Dakota Retirement System (SDRS)								
(e) SDRS slow repayment	66	112	12%	19%	99	91	(8.2)	(9.3)
(f) SDRS fast repayment	72	128	23%	36%	100	93	(7.4)	(9.2)
Contingent employee contribution								
(g) Shared-risk employee contribution	101	216	31%	73%	*	*	*	*

Policy descriptions

(a) Constant COLA 1.5% -- fixed 1.5% annual COLA; the baseline against which we compare other policies

(b) Contingent COLA: return -- 0% COLA when prior-year investment return < 7.5%, 2% when prior return >= 7.5%

(c) Contingent COLA: funded ratio threshold -- 0% COLA when prior-year funded ratio < 90%, 2% when prior ratio >= 90%

(d) Contingent COLA: funded ratio ramp -- 0% when prior-year funded ratio < 70%, 0 to 2% as ratio rises to 90%, 2% when ratio >= 90%

The 2 policies styled on the South Dakota Retirement System have 1.5% baseline COLA, 0% floor & 2% ceiling. The assumed corrective actions differ:

(e) SDRS slow repayment. 15-year open level-dollar amortization of shortfall, with equal employer and employee contribution increases

(f) SDRS fast repayment. 5-year open level-dollar amortization of shortfall, with equal employer and employee contribution increases

(g) Shared-risk employee contribution -- COLA is 1.5% every year. Employee contribution is adjusted every 3 years +/- 0.5% of pay based on 10-year returns. Maximum total adjustment +/- 2% of pay.

* Benefits are same as in baseline policy, but employee contribution costs are different.

Looking down the left column of any two-column group shows how a risk-sharing policy compares to the baseline policy in the first row. Comparing the left and right columns in the group shows what happens as we move from the median or typical simulation to a bad scenario (here defined as the 90th percentile for employers and the 10th percentile for plan members). The body of the paper examines these and other measures in detail. Here we summarize key conclusions.

Contingent COLA policies:

- Moderate protection against high employer cost in bad return scenarios: Compared to the baseline policy, all three contingent COLA policies lead to lower present value of employer contributions in bad scenarios - their present value, at the 90th percentile, is well below the baseline policy present value. Their value at the median is closer to the baseline than it is in bad scenarios.
- Little protection against short-term employer contribution volatility: The baseline policy's worst-5-year-increase in employer contributions is 32 percent of payroll in the median simulation and 72 percent at the 90th percentile, more than doubling in bad-return scenarios. The worst-5-year increases are similar for the contingent COLA policies - they provide little protection against short-term volatility.
- Members face risk of substantially lower benefits over their lifetimes and over short time periods: Comparing the median and 10th percentile columns shows that the two policies triggered by low funded ratios can result in substantially lower lifetime benefits in bad scenarios. Furthermore, benefit reductions can come relatively quickly - at the 10th percentile, all three policies lead to declines of 9 percent in inflation-adjusted benefits within a 5-year period. These policies also entail upside potential for members, as the body of the paper discusses.

Policies styled after South Dakota Retirement System COLA policies:

These policies have lower employer contribution cost and lower employer contribution volatility than the other risk-sharing policies. While benefit risk to members is not much greater than in the other risk-sharing policies, this tells only part of the story. When these policies cannot achieve full funding through COLA reductions, corrective action is required. Our analysis assumes that contribution increases would be required of both employers and employees. Because corrective action often will be required, members will face both benefit-reduction risk and contribution-increase risk. The impact of the policies is highly dependent on assumptions about who will bear the impact of corrective actions and over what time period.

The contingent employee contributions policy:

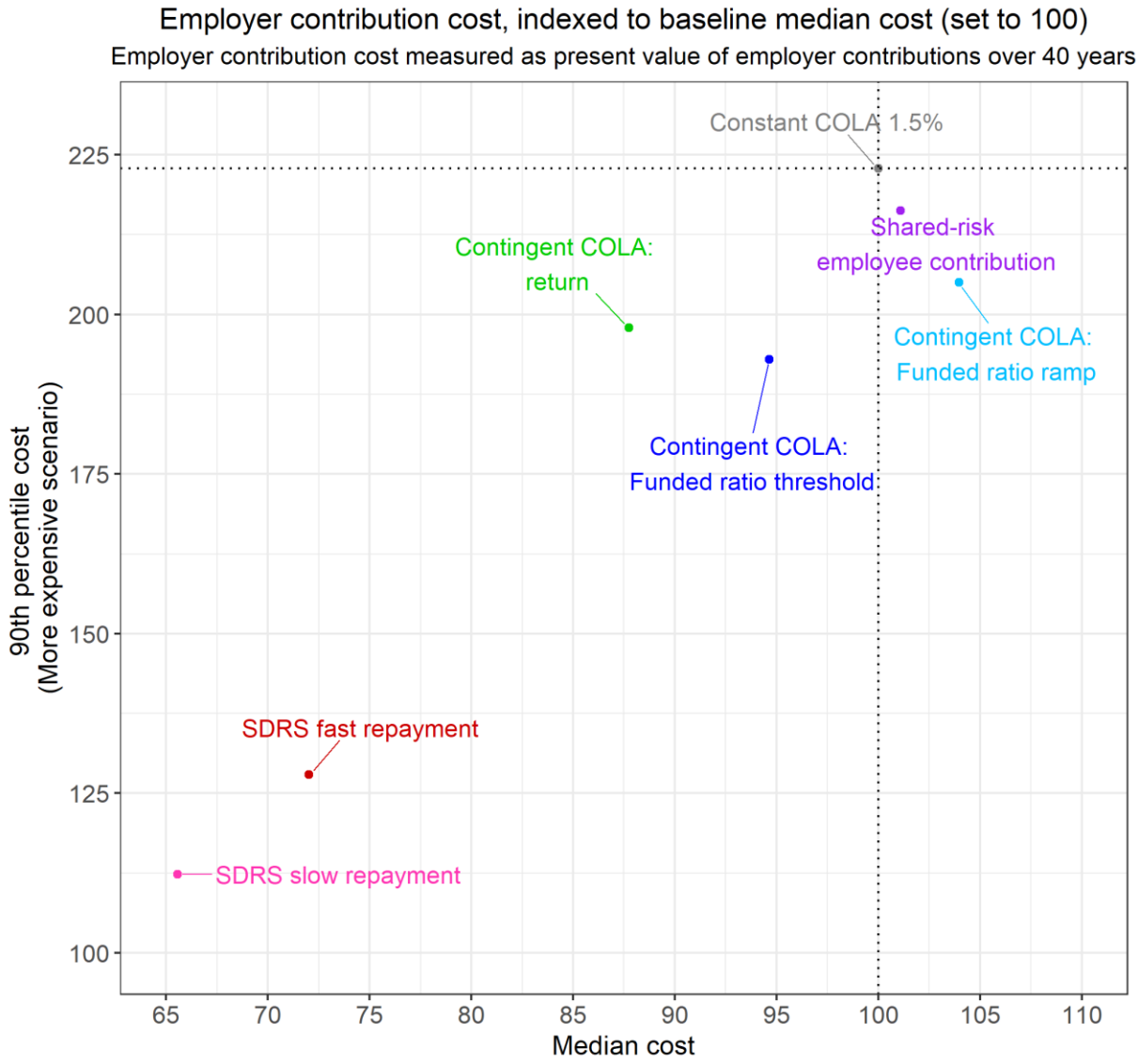
The contingent employee contributions policy we examined had relatively little impact on employer contribution volatility and total employer cost. They have no impact on member benefits but increase member contribution cost. We will examine the costs and risks to members of contingent employee contributions in future work.

8.4 Illustrations of impacts on employers

Figure 21 summarizes the present value of employer contribution costs at the median and 90th percentiles, indexed to the median baseline cost. It shows that all of the risk-sharing policies we examined are less expensive than the baseline in adverse circumstances (at the 90th percentile -- they fall below the

dotted horizontal line); nonetheless, several are more expensive than the baseline at the median outcome (to the right of the dotted vertical line).

Figure 21. Present value of employer contributions



Most of the policies would have little impact on the short-term volatility of employer contributions. The major exceptions are the two policies styled after the South Dakota Retirement System (SDRS) policy, striving to maintain full funding through annual adjustments to COLAs.

Figure 22 shows the maximum employer contribution increase in any 5-year period over our 40-year simulations, under each policy, at the median simulation out of 1,000 simulations and at the 90th percentile. The SDRS-like policies have much smaller maximum employer contribution increases than all the other policies.

Figure 22. Maximum employer contribution increase in any 5-year period

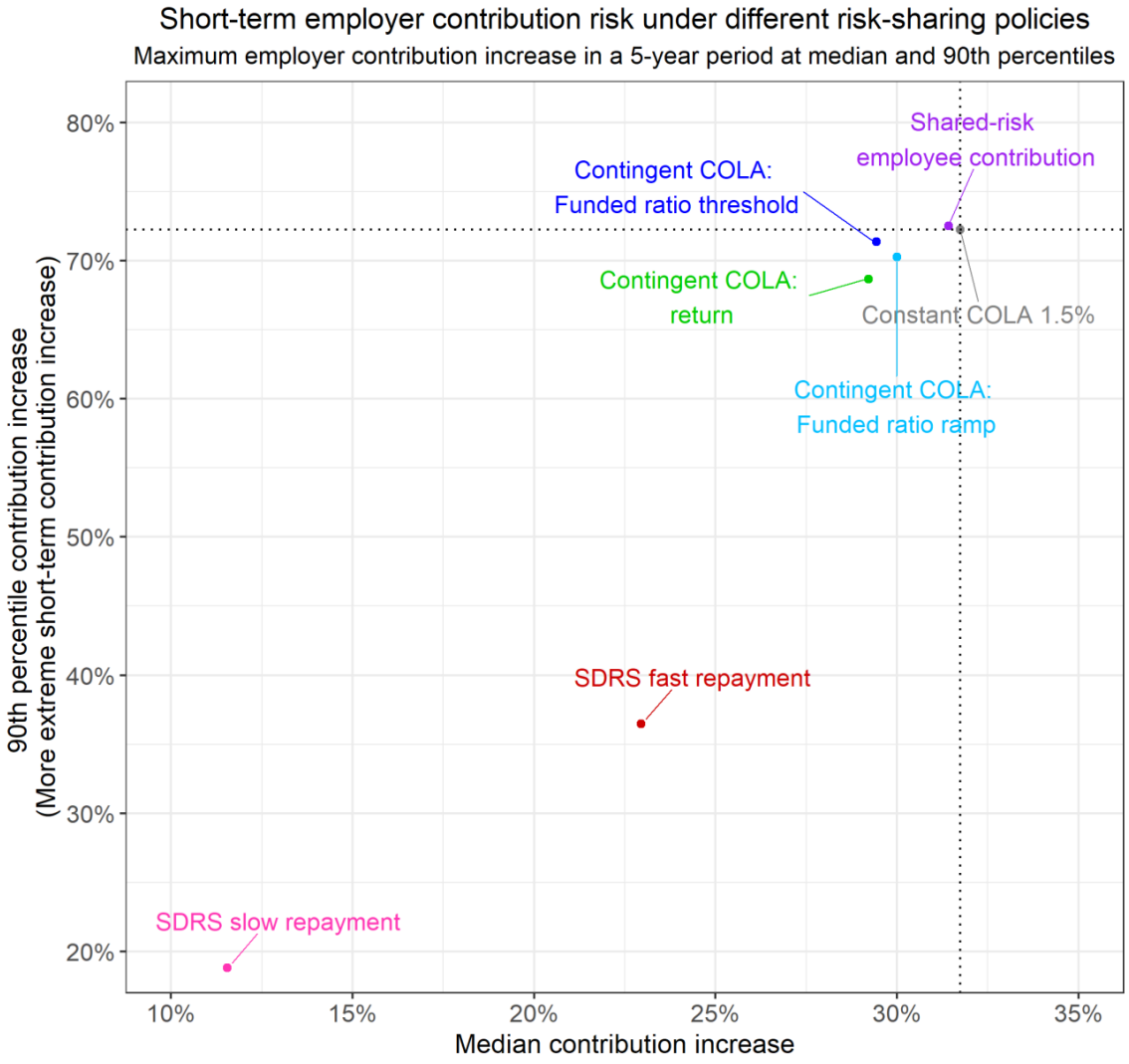
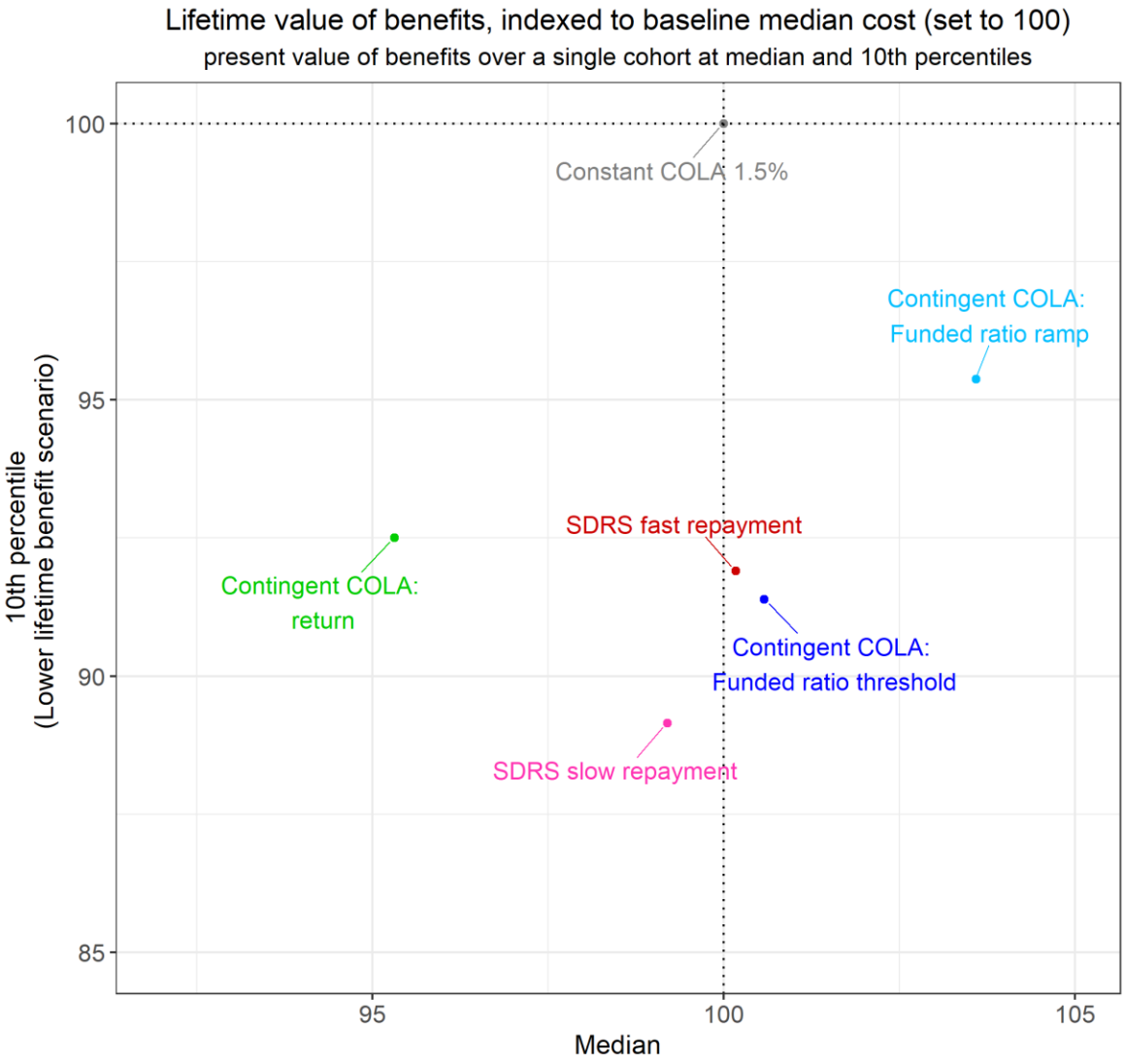


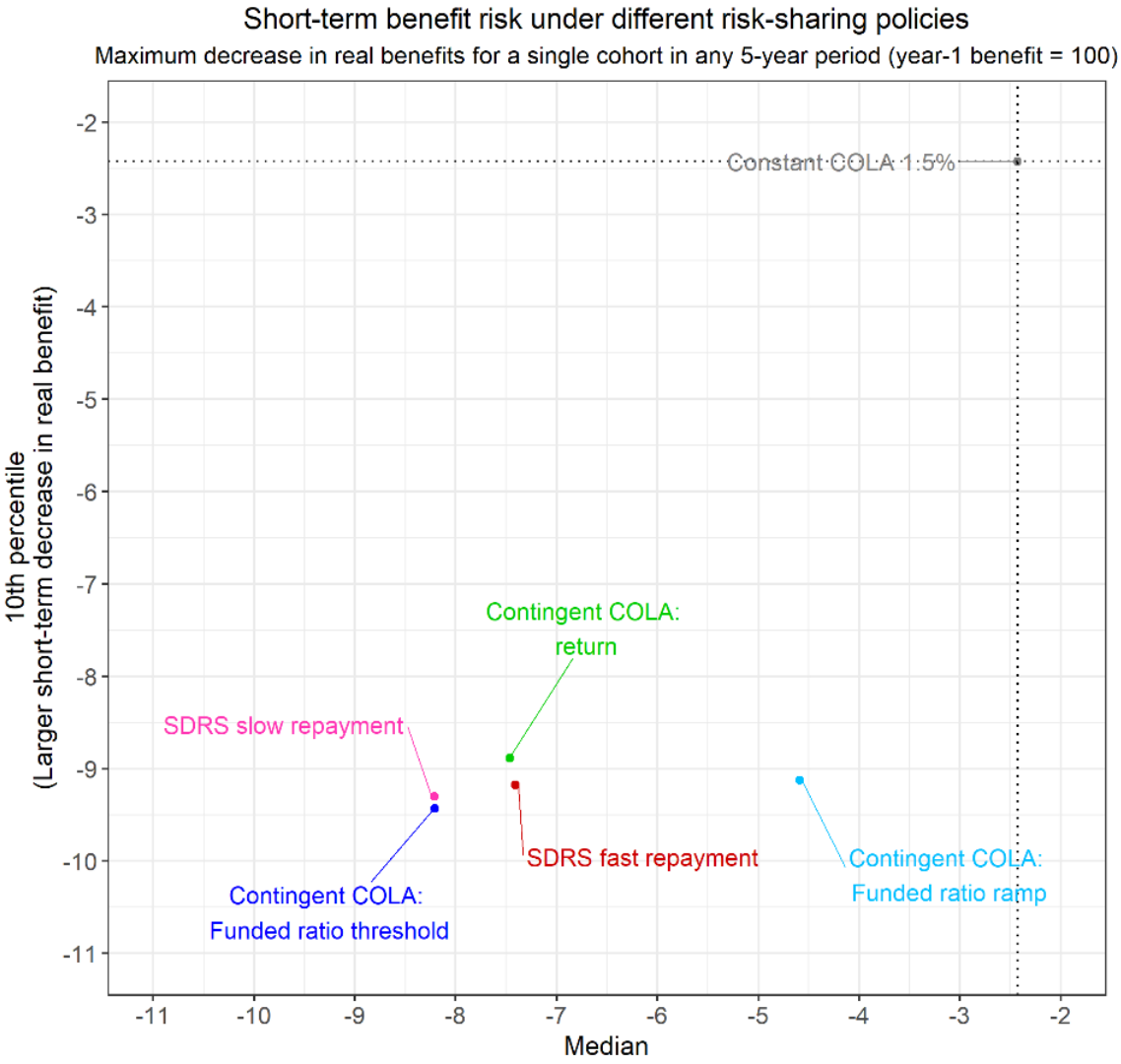
Figure 23 summarizes the lifetime value of benefits at the median and 10th percentiles, indexed to the median benefit value under the baseline policy. The contingent employee contribution policy does not affect benefits and is therefore excluded from this figure. It shows that the policies we examined lead to substantial risk of low benefit values compared to the baseline in adverse circumstances (see the 10th percentiles, they are lower than the dotted horizontal line by 5 to 11 percentage points). At the median outcome, several policies provide higher lifetime value of benefits than the baseline (to the right of the dotted vertical line).

Figure 23. Present value of lifetime benefits for a single cohort



Retirees also face substantial risk that the real value of benefits will fall quickly in a short period of time under all the policies we examined. Figure 24 shows the maximum decrease in inflation-adjusted benefit for a single cohort in any 5-year period over our 40-year simulations, under each policy, at the median simulation out of 1,000 simulations and at the 90th percentile. The benefit in the first year of retirement is indexed to 100. In adverse circumstances (10th percentiles), all policies can lead to losses of purchasing power of about 9 percent of the initial benefit within a 5-year period. At the median outcomes, the maximum 5-year decline in real benefit ranges from 4.5 percent to 8 percent of the year-1 benefit.

Figure 24. Maximum decrease in real benefits for a single cohort in any 5-year period



9. Overall conclusions

We consider our simulation results preliminary but informative. Our main conclusions are:

- The contingent COLA policies we examined, other than the stylized SDRS-like policies, reduce the volatility of employer contributions only marginally. The impact of these policies is more significant during dramatic market downturns than during more-normal market conditions.
- The contingent COLAs we examined could create a significant benefit risk for retirees. During downturns, retirees could experience low benefits during retirement. The acceptance of contingent COLA policies depends on the risk tolerance and risk preference of plan members and policymakers.
- The contingent employee contributions policy we examined, styled after policies in Pennsylvania state retirement systems, also has relatively little impact on employer contribution volatility and total employer cost.
- The complex policies styled loosely after the South Dakota Retirement System risk sharing arrangement, which seek to achieve full funding by adjusting the COLA within a ceiling and a floor, have much bigger impacts. They have lower employer costs and risks than the other risk-sharing policies we examined. These policies require "corrective action" if full funding cannot be achieved at the floor COLA. The impact of the policies is highly dependent on these corrective actions; we modeled two hypothetical actions that split the shortfall 50-50 between employers and employees.
- Put simply, the specific design of a risk-sharing policy will have large effects on its impact.
- Finally, in some instances, introduction of a risk-sharing policy when a plan is deeply underfunded may be less about reducing risk and more about reducing cost: a policy that provides some benefit upside potential but substantial downside, with a COLA floor of zero, may be intended to reduce costs and benefits substantially relative to a fixed COLA. In addition, employers may utilize the interaction between risk-sharing mechanisms and other plan policies to further reduce cost. For example, the funded-ratio-triggered COLA policies can create incentive for employers to seek a lower discount rate: the lower discount rate would result in higher actuarial liability and a lower funded ratio, making COLAs less likely to be triggered and therefore reducing future benefit payouts. It also could make it easier for a plan to take less investment risk.

ENDNOTES

1. For examples of the former, see "Cost-Sharing Features of State Defined Benefit Pension Plans: Distributing Risk Can Help Preserve Plans' Fiscal Health." and "NASRA Issue Brief: State Hybrid Retirement Plans" (National Association of State Retirement Administrators, December 2017). For an example of the latter, see Dennis Bams, Peter C. Schotman, and Mukul Tyagi, "Optimal Risk Sharing in a Collective Defined Contribution Pension System," SSRN Electronic Journal, 2016, https://doi.org/10.2139/ssrn.2766486.
2. The model assumptions are similar to those used in Boyd and Yin (2016).
3. Among the actuarial valuation reports of seven representative plans with contingent COLA policies we have reviewed, two plans explicitly state that the actuarial equivalent COLA rates used their valuations are determined through stochastic simulation approach (Louisiana TRS and Minnesota PERS), and others just provided the COLA assumption used in valuation without further explanation.
4. An alternative measure of plan cost also includes the Unfunded Actuarial Accrued Liability (UAAL) in year 40, which represents the outstanding funding gap that eventually needs to be made up beyond the final simulation year. We did not include the terminal UAAL in our cost measure for the following reasons: 1) our analysis focuses on the realized plan costs to employers during the simulation period; 2) the terminal UAAL could be shared by the employer and employees (through contribution increases and benefit cuts) in the long term and there is great uncertainty in how the UAAL might be apportioned between the employer and employees; 3) as our model does not allow for negative contributions (withdrawal from the fund) even when large surplus exists, a large proportion of the simulations include large negative terminal UAALs (surplus), which can make the comparison across policies more difficult to interpret.
5. See Fiddler, Schrader and Wylie (2018) for a good discussion of the current SDRS policy.
6. See "Managing SDRS Based on Fixed, Statutory Contributions" https://sdrs.sd.gov/docs/SDRSFundingPolicy.pdf
7. We only focus on the flexible COLA component of the SDRS flexible benefit arrangement and exclude the variable retirement account. We do not allow for benefit changes when the funded ratio falls below the threshold for corrective action. Instead, the plan makes additional contributions when corrective actions are needed. We do not model the funding requirement for normal cost. No actuarial gains/losses except for investment gains/losses in the model as demographics and salary change based on the decrement tables and salary assumptions.
8. The "Contingent COLA: Funded ratio ramp" determines COLA based on a linear ramp of funded ratio between 90 percent (full COLA) and 70 percent (0 COLA); the two SDRS-type policies determine COLA based on a non-linear funded ratio (based on the 1.5 percent baseline COLA) ramp between 100 percent (full COLA) and about 86 percent (0 COLA).
9. There are small actuarial gains due to the actual annual COLAs are lower than the assumed COLA of 1.5 percent, which slowly drives COLAs up.
10. In a sense, the "corrective action" contributions under the SDRS-like policies are equivalent to the amortization contributions under other policies that are entirely made by employers.
11. Note that the SDRS-policies have higher compound annual COLAs compared to the baseline policy but similar median present values of benefits. It can be shown that cash flows with the same compound annual growth rate may result in different total values: generally, the more backloaded the cash flow the lower the total value. The higher median compound annual COLA and the lower present value of benefit under the SDRS-policies compared to the baseline constant COLA policy may suggest generally more backloaded benefit streams under the SDRS-type policies in the simulations.

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