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PENSION SIMULATION PROJECT

INVESTMENT RETURN VOLATILITY AND THE UNIVERSITY OF CALIFORNIA RETIREMENT PLAN

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Executive Summary

Public pension funds invest in stocks, bonds, and other assets with the goal of accumulating sufficient funds, in combination with employer and employee contributions, to pay benefits when due. Investments can entail risk, and contributions may have to be adjusted to ensure that assets are sufficient to pay benefits. State and local governments generally backstop public pension funds, paying higher contributions when investment returns are below expectations, or lower contributions when investment returns are above expectations. Thus, taxpayers and those who benefit from government services and investments bear the consequences of this investment risk. The Rockefeller Institute of Government's Pension Simulation Project is examining the potential consequences of investment-return risk for public pension plans, governments, and stakeholders in government.

In this report, we examine the potential implications of investment return volatility for the University of California Retirement Plan (UCRP). We selected UCRP as one of five plans to analyze in detail. UCRP has many characteristics that are similar to typical or average plans. The other plans include a deeply underfunded plan, a very well-funded plan, a closed plan, and a public safety plan. Our analysis is independent of UCRP, and is neither sponsored nor approved by UCRP, although we have communicated with their staff.

There are many important features of UCRP that have entered into our analysis, but the three most important are: (1) its funded ratio based on value of assets (83 percent for the segment we model) is better than most plans; (2) it amortizes actuarial gains and losses using level-dollar closed-period amortization, and asset values are smoothed over five years; and (3) the University's current practice is to cap annual employer contributions at 14 percent of payroll and require employer contributions to at least equal employee contributions; this practice could change in future years.

We model the finances of UCRP, and potential contributions from the University of California, under several investment scenarios, including the following:

1. The plan achieves its investment return assumption of 7.25 percent each and every year.

2. The 7.25 percent return assumption is correct on average but varies from year to year. The standard deviation — a measure of how much returns vary from year to year — is 12 percent in this scenario.

3. A scenario in which expected returns are below 7.25 percent for six years, due to the current low-interest-rate environment, and then rise.

4. A scenario in which expected returns are below 7.25 percent for fifteen years, due to an extended low-return environment, and then rise.

5. A scenario, consistent with some current market forecasts, in which investment return volatility is 16 percent, rather than 12 percent.

6. A scenario constructed by applying a publicly available set of capital market assumptions to the current UCRP portfolio.

We examine these scenarios under the current funding practice, in which the employer contribution is capped at 14 percent of payroll, and alternative approaches in which the cap is removed. We use two main measures of risk: (1) the probability that at some point in the next thirty years the market value funded ratio will fall below 40 percent, which we consider to be a crisis level; and (2) the probability that the employer contribution will rise sharply in a short time period, increasing by more than 10 percent of payroll within any five consecutive year period over the next thirty years.

Our analysis shows that:

■ If assumed investment returns are achieved each and every year, the plan will move toward full funding with contribution amounts as expected.

■ Realistically, even if assumed returns are achieved on average in a single simulation, investment returns will vary significantly from year to year, potentially leading to years of substantial underfunding even in simulations in which, after thirty years, compound annual investment returns exceed assumed returns. In simulations in which the assumed return is not achieved over thirty years, volatility can be greater and outcomes worse.

■ If assumed returns are correct on average over the long run, but have a 12 percent standard deviation, then under current funding practice with employer contributions capped at 14 percent of payroll:

● There is a nearly one in four chance that the *funded ratio* will fall below 40 percent — what we consider to be crisis territory — sometime between now and year thirty.

● *Employer contributions* remain stable and relatively low because of the current 14 percent cap.

■ Under the same investment assumptions, if the employer does not cap contributions at 14 percent:

● There is only about a two percent chance of the *funded ratio* falling below 40 percent.

● There is about a one in two chance that employer contributions will increase by more than 10 percent of

payroll within a consecutive five-year period. With no contribution cap, the employer bears the risk of investment shortfalls, through higher contributions, that currently is borne by the plan.

■ Under the alternative investment return scenarios based on more realistic capital market assumptions, which generally have either lower expected returns or greater investment return volatility:

● There is a more than one in three chance that the *funded ratio* will fall below 40 percent in the next thirty years, if the practice of capping employer contributions at 14 percent of payroll is maintained.

● If the practice of capping contributions is eliminated, the chance of the *funded ratio* falling below 40 percent falls significantly, while there is about a 50 to 70 percent probability that the *employer contribution* will rise sharply, increasing by more than 10 percent of payroll in at least one consecutive five-year period over the next thirty years, depending on the specific alternative funding policy and practice and on how much lower than 7.25 percent expected returns are.

These simulations suggest that there is considerable risk to UCRP funding if the plan maintains the practice of capping employer contributions at 14 percent of payroll even when the plan's investment-return assumptions are correct on average over the long run. Under plausible alternative investment return assumptions, the risks are greater still. To reduce these risks to plan funding, the University may wish to adjust its contribution practice to allow greater responsiveness to investment results; other plans with rigid contribution policies and practices may wish to do the same. In addition, the fund may wish to examine its risk profile carefully, with an eye toward reducing investment return volatility. Doing so would require higher employer contributions, but would lead to more secure funding of benefits. Many other plans are in a similar situation and should consider their risk profiles carefully as well.

INVESTMENT RETURN VOLATILITY AND THE UNIVERSITY OF CALIFORNIA RETIREMENT PLAN

Introduction

Public pension funds invest in stocks, bonds, and other assets with the goal of accumulating sufficient funds, in combination with employer and employee contributions, to pay benefits when due. Investments can entail risk, and contributions may have to be increased, or may be decreased, to ensure that assets are sufficient to pay benefits.

When a pension fund invests in a portfolio of assets that entail risk, expected investment returns generally will be higher than for investments in risk-free assets. And if expected returns are achieved, contributions will be lower than they otherwise would be. The disadvantage is that expected returns are not guaranteed returns, neither over short time periods nor even over the long run.

Depending on how volatile investment returns are, funded ratios may rise or fall significantly, and required contributions may fall or rise considerably. The extent and timing of these changes will depend in part upon methods used to determine contributions. If adverse movements are too large, funded ratios could become so low that they create political crises. In some states, this

would lead to pressure to cut benefits. (Benefit cuts are unlikely in California due to the legal protections afforded pensions.) Adverse movements could cause requested contributions to increase so much that they create fiscal stress for employers, leading to pressure for substantial increases in taxes or other revenue, cuts in spending, or other undesirable outcomes. Alternatively, investment returns above expectations could lead to very high funded ratios and very low required contributions.

How much risk is too much risk? There is no magic rule. Plans, employers, and other stakeholders need to weigh the potential risks and rewards. The key to making these decisions is to understand risks, evaluate risks, and communicate that analysis to those affected.

In this report, we examine the potential implications of investment return volatility for the University of California Retirement Plan (UCRP). We selected UCRP as one of five plans to analyze in detail in our Public Pension Simulation Project. The five plans have a broad range of characteristics. UCRP has many characteristics that are similar to typical or average plans. The other plans include a deeply underfunded plan, a very well-funded plan, a closed plan, and a public safety plan.

Risks can be positive or negative, and we examine both in this report. However, we pay particular attention to the consequences of investment return shortfalls because shortfalls can be extremely problematic for pension plans, beneficiaries, policymakers, and government stakeholders.

To evaluate risks, we focus primarily on the market-value funded ratio and on employer contributions (ERC) as a percentage of payroll, and the probability that either may change considerably over time or enter into dangerous territory. We examine UCRP finances under the current funding policy and practice and several alternatives, and we examine different investment return scenarios.

Our Pension Plan Simulation Model

We have developed a simulation model that can be used to evaluate the implications of investment risk. The model calculates the annual cash flows and fiscal position of a public pension plan for future years. Typically, we run a simulation for fifty years or more, but focus our analysis on the earlier years. Each year the model starts with beginning asset values and computes ending assets by subtracting benefits paid, adding employee and employer contributions (including any amortization), and calculating investment income.

The model keeps track of these values and other variables of interest, such as the funded ratio and employer contributions as a percentage of payroll. It saves all results so that they can be analyzed after a simulation run in any way desired.

The model is quite flexible:

- Benefits can be calculated within the model using rules of the plan (e.g., benefit factors and retirement ages), plan demographics, chosen mortality tables, and other actuarial assumptions. Multiple tiers can be modeled. Alternatively, the model can import projections of annual benefit payments that have been prepared by an actuary or the model user.

- Contributions can be determined actuarially under commonly used funding policies. The user can decide the length of the amortization period and whether it is open or closed, as well as whether the amortization payment is a level percentage of payroll, or a level dollar amount. Asset smoothing can be allowed, or not. Actuarially determined contributions can be constrained by caps and floors, or overridden completely and set as a fixed percentage of payroll. We do not allow contributions to be negative (employers cannot withdraw assets from the fund).

- Accrued actuarial liabilities can be calculated under several common cost methods.

- The plan can be modeled as closed, or new employees can be brought in each year to achieve a target for annual growth in the number of active members.

Investment returns are determined flexibly as well, and can be:

- **Fixed (i.e., deterministic):** for example, 7.25 percent every year

- **Stochastic:** for example, 7.25 percent expected return in every year, with a 12 percent standard deviation, drawn from a normal distribution. ("Stochastic" means that returns are random and follow a specific distribution.)

- **Time-varying:** returns can be set to a fixed value each year, but that value may vary from year to year — for example 5 percent annually for the first five years, then 6 percent annually for the next five years, then 8 percent for the next forty years.

- **Time-varying and stochastic:** for example, expected return of 5 percent in the first five years with a standard deviation of 8 percent, followed by expected return of 6 percent for the next five years with a standard deviation of 10 percent, followed by expected return of 8 percent with a standard deviation of 12 percent for the next forty years.

When investment returns for a scenario have a stochastic component we run 2,000 simulations, each with a different set of annual investment returns (drawn from the same assumed probability distribution), so that we can examine the distribution of results. Each simulation results in different investment earnings, leading to different funded ratios and contribution requirements. By examining the 2,000 different sets of results we can gain

insight into the probability of different outcomes. For example, we examine the probability that the funded ratio will fall below 40 percent anytime during the first thirty years — a level that has been associated with crisis in other states.

Table 1 illustrates possible investment returns for a scenario with a 7.25 percent expected return and a 12 percent standard deviation.[1] Returns vary randomly from year to year and from simulation to simulation, even though the expected return is the same. Some simulations may produce much better outcomes for a pension plan than others. For example, simulation #3 clearly has much lower returns in the first two years than simulation #1; as a result, in our model assets and the funded ratio would be lower at the end of year two in simulation #3 than in #1.

Table 1. Investment Returns in the Model Can Vary Greatly From Year to Year and From Simulation to Simulation					
Illustration of investment returns used to calculate pension fund finances					
2,000 simulations of a given scenario, returns drawn from a normal distribution with mean 7.25%, standard deviation 12%					
	Simulation year				
Simulation number	**1**	**2**	**3**	**…**	**49**	**50**
1	24.7%	17.1%	2.7%	…	10.8%	36.0%
2	5.5%	15.1%	-1.8%	…	39.4%	-0.7%
3	-15.3%	-11.4%	-0.9%	…	2.1%	-4.2%
…	…	…	…	…	…	…
1,999	7.9%	8.5%	18.2%	…	-20.2%	17.0%
2,000	15.6%	-1.4%	-8.9%	…	23.5%	-6.5%

Source: Authors' generation of random investment returns

About the University of California Retirement Plan[2]

Key Features of UCRP

The University of California Retirement Plan (UCRP) is a defined-benefit pension plan within the University of California Retirement System. As of 2015, it had 123,768 active members employed at the University's ten campuses, five medical centers, Lawrence Berkeley National Laboratory, and Hastings College of the Law. In addition, UCRP had 75,165 terminated vested or terminated nonvested members and 67,321 retirees and other beneficiaries.

UCRP had more than $55 billion of assets in 2015, and paid $2.5 billion in benefits.[3] Its market-value-of-assets funded ratio was approximately 83 percent — better than average, and just below the 75th percentile among large plans.[4,5] Its unfunded liability was $10.8 billion.

UCRP has several retirement tiers, the largest of which is the "1976 Tier," accounting for about 75 percent of actives, followed by two 2013 tiers that together account for about 22 percent of

actives. Benefits generally are calculated using the highest average pay in a thirty-six consecutive-month period. The benefit per year of service can range from 1.10 percent of final average pay to 2.50 percent, depending upon retirement age and tier. The overall UCRP normal cost is 17.7 percent of payroll.[6]

Funding Approach

UCRP currently uses the following approach to funding. First, the independent actuary determines a "total funding policy contribution." This is an actuarially determined amount, although the contribution actually paid may differ from this actuarially determined contribution. The key features of the actuarially determined contribution are:

- Actuarial gains and losses are amortized using level-dollar closed amortization.[7]
- Asset values are smoothed over five years.
- The actuary's calculation is based on the nonlaboratory segment of UCRP (campuses, medical centers, and the Hastings College of the Law). The laboratories have separate funding policies based on contracts with the U.S. Department of Energy.

The University does not necessarily pay the amount calculated by the actuary. The Regents of the University determine the amount to be paid each year, and how the total is to be split between members and the University. The Regents can take into account several factors, including the actuary's calculation of the total funding policy contribution as well as availability of funds. Thus, the University may pay less than the actuarially determined contribution if the Regents conclude that sufficient funds are not available. However, University contributions cannot be lower than member contributions.

The University's recent practice has been:

- Employee contributions have been averaging about 8 percent of payroll. For represented employees, they are subject to collective bargaining.
- University contributions have been a flat 14 percent of payroll.
- In addition, the University has authority to make additional contributions by borrowing from the University's Short Term Investment Pool (STIP). In 2014-15, the Regents approved a transfer of $700 million from STIP which, when added to employer-paid contributions, almost fully funded the actuarially determined contribution.

Investment Return Assumption

UCRP currently uses a 7.25 percent earnings assumption. A substantial majority of UCRP assets is actively managed, generally by external managers. At year-end 2015, approximately 50

percent of assets were in equity, 23 percent in fixed income, and the remainder in other asset classes including real estate and private equity. Total investment return was 4.5 percent in 2015, 17.4 percent in 2014, and 11.7 percent in 2013.

How We Modeled the Finances of UCRP

We modeled the campus and medical centers segment, excluding laboratories, because this segment is governed by a single funding policy while the laboratories have separate funding policies. The campus and medical centers segment accounts for 85 percent of UCRP assets and has extensive data available. We believe it provides a good picture of how the overall finances of UCRP would be affected by investment return volatility and by alternative funding policies and practices.

We model UCRP as an open plan where new employees are hired annually to keep the number of active members constant from year to year. We incorporate a forecast of annual benefit payments that reflects this constant number of active members. Annual benefits vary from year to year, generally increasing, but do not vary across simulations in a single scenario, or across scenarios. We also incorporate a forecast of payroll that is consistent with the benefit payments. We believe these forecasts are consistent with published UCRP characteristics and assumptions.

Funding Approach Scenarios

We examine three funding approaches: (1) current UCRP funding policy and practice, (2) current practice but without the 14 percent of payroll upper bound on employer contributions that has been the University's practice (hereafter referred to as a cap), and (3) the same as (2) but with the lower bound on employer contribution removed. The 14 percent cap protects the finances of the employer but therefore creates greater risk for the finances of the pension fund. We explore this risk in our analysis below.

We model current practice as follows:

- Employee contributions are a fixed 8 percent of payroll.
- Employer contributions are determined in two steps:
  - The model calculates a slightly simplified version of the actuarially determined contribution described earlier: new gains and losses occurring in the simulation period are amortized over a closed twenty-year period using level dollar repayment. Asset values are smoothed over five years.[8] We have not implemented a provision that would amortize surpluses over fifteen or thirty years.
  - The employer pays the employer share of the actuarially determined contribution, subject to (a) a *14 percent of payroll cap*, consistent with current practice of a 14 percent flat contribution; and (b) a requirement that *employer contributions must at least equal the employee contributions*, as is currently required.[9]

As discussed in our analysis below, the current practice, if continued unchanged in the face of adverse investment returns, entails considerable risk of severe underfunding. The University of California might well increase contributions above the current 14 percent level if investment returns fall short, but because this sort of adjustment depends on decisions of individuals rather than on a formal contribution policy, we do not attempt to model it.

To model our alternatives, we simply remove the 14 percent cap on employer contributions in the second funding approach, and remove the cap and the rule that employer contributions must be at least as great as employee contributions in the third funding approach.

Investment Return Scenarios

The UCRP actuarial valuation assumes that the annual investment return will be 7.25 percent. We model this deterministic scenario plus a stochastic version in which the expected long run compound return is 7.25 percent and the annual standard deviation is 12 percent.[10,11]

Many other outcomes also are possible, and we examined two kinds of variants.

The first variant presumes that it is extremely difficult to achieve assumed returns in the short run, even if they may be achievable in later years. In the current low inflation and low interest rate environment, it may be plausible for expected returns to be quite low for the next several years, and then gradually rise, perhaps as the Federal Reserve Board raises short-term interest rates. We developed several such scenarios.

The second variant examines alternative return-volatility profiles, based on our analysis of publicly available capital market assumptions. The standard deviation of 12 percent used in the scenarios described above is lower than the volatility assumption used in several other investment-return analyses when the expected return is at the level assumed by UCRP, and could understate the potential risk. Based on our review of investment-return analyses performed elsewhere, we developed a scenario with expected compound return of 7.25 percent and a standard deviation of 16 percent.[12] We developed another scenario that has volatility a bit below 12 percent, but that leads to a lower expected return. We developed this scenario by applying a publicly available set of capital market assumptions to the UCRP portfolio. This scenario has an expected compound return of about 6 percent and a standard deviation of 11 percent.[13]

Table 2 shows six of the investment-return scenarios we modeled. The first two columns label and describe the simulation. The next two columns show the expected compound return during subperiods of the first thirty years. The next column shows the expected compound return over the full thirty years and the final column shows the standard deviation.

	Table 2. Investment Return Scenarios					
	Return scenario	Description	Year	Expected compound annual return for the period in question	Expected compound annual return over entire simulation period	Standard Deviation
1	**Assumption achieved: Determinstic**	Return assumption is met each and every year	1-30	7.25%	7.25%	0%
2	**Assumption achieved: Stochastic**	Constant expected return over 30 years that meets the actuarial assumption	1-30	7.25%	7.25%	12%
3	**6 years of low returns**	Starting with a relatively short period of low expected return (year 1-6)	1 2 3 4 5 6 7-30	5.000% 5.375% 5.750% 6.125% 6.500% 6.875% 7.250%	about 6.9%	12%
4	**15 years of low returns**	Starting with a relatively long period of low expected return (year 1-15)	1-10 11-15 16-30	4.50% 6.50% 7.50%	about 6.4%	12%
5	**High volatility reflecting market forecasts**	High volatility reflecting current market forecasts based on market assumptions from private consulting firms	1-30	7.25%	7.25%	16%
6	**Low expected return based on UCRP portfolio**	Low expected return based on applying current captial market assumptions to UCRP portfolio	1-30	6%	6%	11%

Notes: When expected returns are not constant over the entire simulation period (scenario 3 and 4), the approximate formula for calculating expected compound annual return is not readily availalble and the expected compound annual return is obtained by simulation approach (close to the mean of 50,000 simulations).

Measures We Use to Evaluate Results

We are primarily concerned about two kinds of risks:

- Extremely low funded ratios, which create a risk to pension plans and their beneficiaries, and create political risks that could lead to benefit cuts in states in which cuts are legally permissible (this is not likely in California because of strong legal protections for pension benefits); and

- Extremely high contributions, or large increases in contributions in short periods of time, which pose direct risks to plan sponsors and their stakeholders, and in turn could pose risks to pension plans and their beneficiaries.

There usually are trade-offs between these two kinds of risks. If a pension plan has a contribution policy designed to pay down unfunded liabilities very quickly, it is unlikely to have low funded ratios but it may have high contributions. If a pension plan has a contribution policy designed to keep contributions stable and low, there is greater risk that funded ratios may become very low because contributions may not increase rapidly in response to adverse experience.[14]

We use several measures to evaluate these risks, two of which we describe below. We include others in an appendix.

Probability That the Funded Ratio Will Fall Below 40 Percent During the First Thirty Years

When returns are stochastic, many outcomes are possible, including very extreme outcomes, so it does not make sense to focus on the worst outcomes or the best outcomes. We are particularly concerned about the risk of bad outcomes, and one useful measure is the probability that the funded ratio, using the market value of assets, will fall below 40 percent in a given time period.

We choose 40 percent because it is a good indicator of a deeply troubled pension fund. In 2013, only four plans out of 150 in the Center for Retirement Research's Public Plans Database had a funded ratio below 40 percent — the Chicago Municipal Employees and Chicago Police plans, the Illinois State Employees Retirement System, and the Kentucky Employees Retirement System. Each plan is widely recognized as being in deep trouble, with the likelihood of either substantial tax increases, service cuts, or benefit cuts yet to come.

In the first year, this probability is near zero. Given UCRP's current level of funding, falling to 40 percent funded would require an investment shortfall of well over 40 percent, which is not likely in a single year. But as the time period extends, there is a chance of an extended period of low returns, leading to severe underfunding. This measure evaluates the likelihood of this occurring.

Probability That Employer Contributions Will Rise By More Than 10 Percent of Payroll in a Five-Year Period

Making contributions stable and predictable is one of the most important goals of funding policies from the perspective of the employer. Sharp increases in employer contributions, even if not large enough to threaten affordability, can cause trouble in budget planning. We use the probability that the employer contribution (including STIP) will rise by more than 10 percentage points of payroll in a five-year period to measure this possibility.

This measure will always be zero under the current UCRP funding approach, because the employer contribution is in a 6-percentage-point corridor — it cannot be lower than the employee contribution of approximately 8 percent, nor higher than 14 percent under current funding practice. In funding approaches free of the 14 percent cap, extremely low returns in a very short time period as may occur in a severe financial crisis may push up the required contribution considerably even after being dampened by asset smoothing and amortization policies.

Results

In our analysis we generally focus on the first thirty years, in the belief that this is a meaningful period for policymakers.

A note on nomenclature: In the tables and graphs that follow, we label each plan fiscal year by the year in which it begins. For example, 2015 is the year beginning July 1, 2015, also called the 2015-16 fiscal year. The year labeled 2044 is the 2044-45 fiscal year.

Comparison of Deterministic and Stochastic Scenarios With Assumed Return Achieved

Results of Scenario 1 "Assumption Achieved: Deterministic"

In the base-case deterministic scenario, the investment return is 7.25 percent each and every year so there are never any unanticipated gains or losses, and a single simulation is all that is needed. It embodies UCRP's key assumptions in important respects and thus forms our base case against which we compare alternatives.

Table 3 shows results for key variables in selected years, generally spaced five years apart. The plan starts out with about an 83 percent funded ratio in the initial year, but the unfunded liability is gradually eliminated so that at the end of thirty years the funded ratio is approximately 100 percent. Employer contributions are 14 percent of payroll annually (with STIP contributions on top of that in the first three years), until the unfunded liability is paid off, after which they fall toward 8 percent, which is the employee contribution rate and thus is the employer contribution floor.

Year	**AL**	**Market value asset**	**Benefit**	**Total Contribution**	**Employee contribution**	**Employer contribution (w/o STIP)**	**STIP**	**Net external cash flow (contribution minus benefit)**	**Funded ratio (market value asset)**	**Employer contribution rate (w/o STIP) as % of payroll**	**Net external cash flow as % of asset**	**Asset to payroll ratio**
2015	56,433	46,629	2,985	2,685	769	1,352	564	-300	82.6	14	-0.6	4.8
2020	72,004	62,785	3,706	2,470	891	1,579	0	-1,236	87.2	14	-2.0	5.6
2025	89,154	79,527	4,918	2,879	1,033	1,846	0	-2,038	89.2	14	-2.6	6.0
2030	107,394	98,272	6,284	3,365	1,202	2,163	0	-2,919	91.5	14	-3.0	6.4
2035	126,560	119,450	7,687	3,946	1,404	2,541	0	-3,741	94.4	14	-3.1	6.6
2040	147,351	144,593	9,078	4,166	1,646	2,520	0	-4,912	98.1	11.8	-3.4	6.8
2044	166,182	165,605	10,111	4,073	1,872	2,201	0	-6,039	99.7	9.0	-3.6	6.8

Table 3. Results From Deterministic Simulation

Note: $ million for dollar values.

Results of Scenario 2 "Assumption Achieved: Stochastic"

In the base-case stochastic scenario, everything is the same as in the deterministic scenario, except that although the expected long-run compound return is 7.25 percent, returns vary from year to year. The funding approach is as described above — actuarially determined, with an 8 percent floor and a 14 percent cap (under current practice).

### *Variability in Investment Returns*

A 12 percent standard deviation results in considerable variability in annual investment returns. On average, about a quarter

of the annual returns will be negative and nearly a sixth will be greater than 20 percent. The investment risk stemming from the variability in annual investment returns is twofold: first, there is uncertainty in the thirty-year annual compound return and there is no guarantee that the expected compound annual return of 7.25 percent will be achieved in any single simulation; second, even when the assumed return is achieved on average over the thirty years, the year-to-year changes in investment returns can still lead to substantial underfunding in certain periods.

Although the annual investment returns are drawn from a statistical distribution with an expected long-run compound return of 7.25 percent, there is no guarantee that the thirty-year compound return will be 7.25 percent in any single simulation — some simulations will be quite bad, some will be quite good, and many will be near the expected average. However, over the 2,000 simulations the average long-run compound return in our model will be approximately 7.25 percent. Figure 1 shows the distribution of compound annual returns at the thirty-year mark. The median compound average return, marked by the red vertical line, is approximately 7.25 percent.

Figure 1. Thirty-Year Compound Returns Are Symmetric Around Average

Distribution of 30−year compound annual return over 2,000 simulations
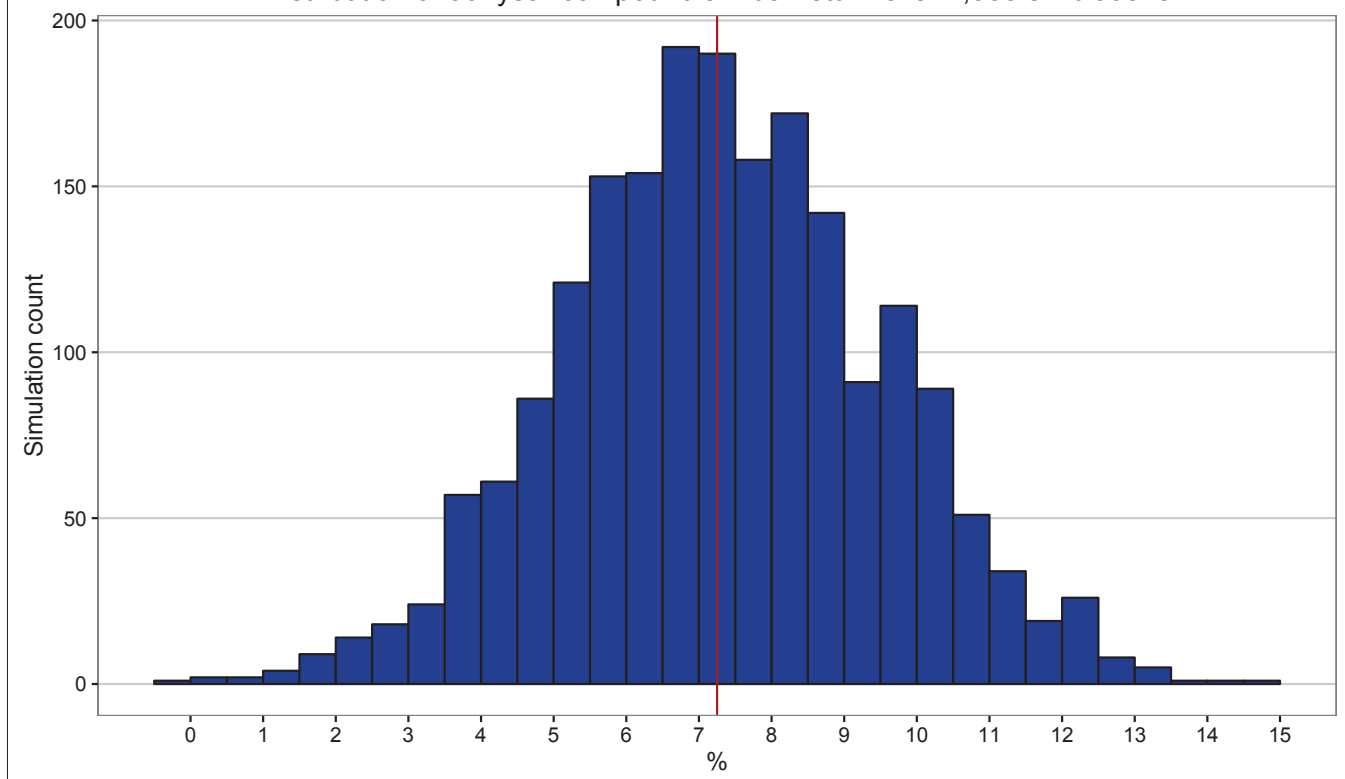
The compound annual return becomes less variable as the investment horizon increases, but this does not suggest investment becomes less risky in the long run. If the simulation horizon is only ten years, about 8 percent of the 2,000 simulations result in

negative annual compound returns; if the simulation period extends to thirty years, the likelihood of negative annual compound return becomes negligible. Although compound returns are less variable in the long run, future asset values become more variable because the impact of compounding investment returns over a longer period outweighs the narrowing of the range around expected returns, causing asset values to be more uncertain as the investment horizon lengthens.

Even if assumed returns are achieved on average in a single simulation, investment returns can vary significantly from year to year, potentially leading to years of substantial underfunding even in simulations in which, after thirty years, investment returns exceed assumed returns. In simulations in which the assumed return is not achieved over thirty years, volatility can be greater and outcomes worse. Examples are shown in an appendix where we analyze four selected simulations from a run of 2,000 simulations.

In the next section we summarize the results of our scenarios, where 2,000 simulations are run under each scenario.

Summary of Stochastic Results

Figure 2 shows the risk of a dangerously low funded ratio under the deterministic scenario and the stochastic scenario. At each year, the graph shows the probability that the funded ratio, based

Figure 2. Once We Allow Investment Returns to Vary, There Is a Significant Risk of Severe Underfunding Even If Expected Return Assumptions Are Correct

Probability of funded ratio below 40% at any time prior to and including the given year
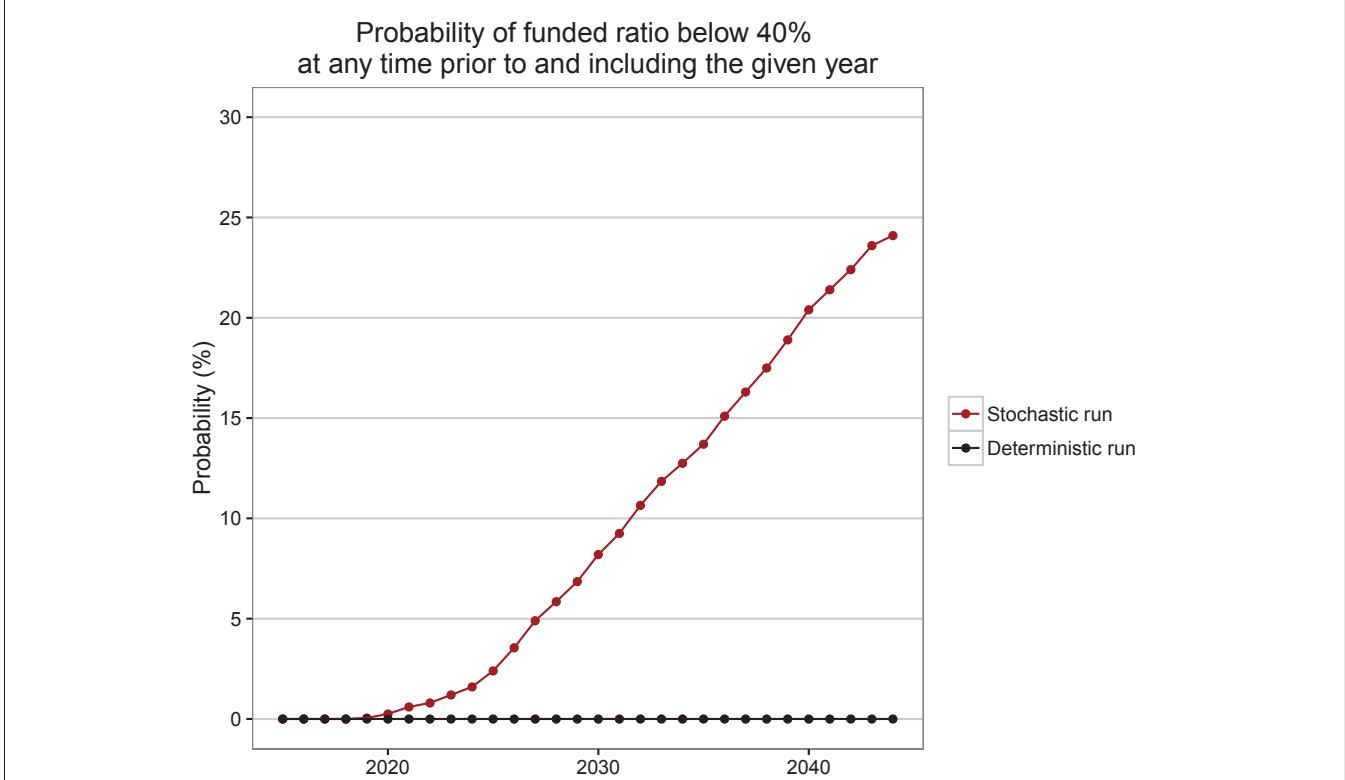
on the market value of assets, will have fallen below 40 percent in any year up to that point. In the deterministic scenario, where investment returns are exactly 7.25 percent in every year, the initial funded ratio is 83 percent and, because there are never any investment shortfalls or overages, the plan marches closer to full funding every year. Thus, the probability of the funded ratio falling below 40 percent is always zero.

In the stochastic scenario, in any single year investment returns will be better than assumed or worse than assumed. In some simulations, investment returns may be worse than assumed for many years in a row. Although contribution policy is intended to put the plan back onto a path toward full funding after investment shortfalls, the combination of the contribution cap, asset smoothing, and a series of bad investment returns can lead to circumstances where plan funding becomes dangerously low. As the figure shows, thirty years into the simulation (2044), there is a 24 percent chance that the funded ratio will have fallen below 40 percent at some point in the period. This is a nearly one in four chance of being in a deeply underfunded situation in the next thirty years, if a 7.25 percent long-run investment return assumption is reasonable, if the standard deviation is 12 percent, and if the current funding practice with employer contributions capped at 14 percent continues.

We do not provide a graph that shows the risk of large increases in employer contributions over short periods of time, which we defined as an increase in employer contributions of more than 10 percent of payroll within five years, because that cannot happen under current practice with an 8 percent floor and a 14 percent cap. However, this measure will be relevant in our comparisons of funding approaches.
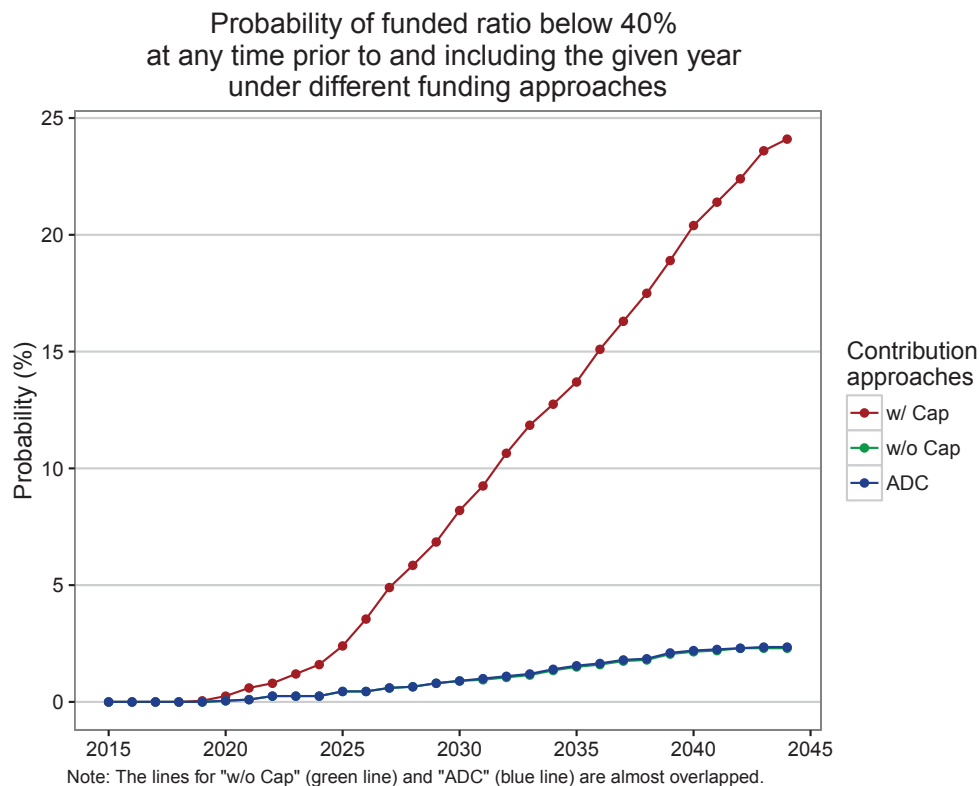
Comparison of Funding Approaches

We compare three funding approaches: (1) the current UCRP policy with the 14 percent employer contribution cap in practice; (2) the UCRP policy without that cap but retaining the 8 percent floor (that is, the requirement to pay at least as much as employees); and (3) the full actuarially determined contribution (ADC) — that is, the UCRP policy with neither the cap nor the floor. All three approaches are simulated under the base-case scenario 2, in which returns are stochastic, with an expected compound return of 7.25 percent and a standard deviation of 12 percent.

In the graphs that follow, these three approaches are labeled as:

- w/ Cap — current policy and practice, with 14 percent cap.
- w/o Cap — current policy and practice with cap removed but 8 percent floor retained.
- ADC — actuarially determined contribution (current policy and practice with cap and floor removed).

Figure 3 shows the probability of the funded ratio falling below 40 percent under these three approaches. The 14 percent cap

Figure 3. A Cap on Contributions Creates a Significant Risk of Severe Underfunding

Probability of funded ratio below 40%
at any time prior to and including the given year
under different funding approaches

Note: The lines for "w/o Cap" (green line) and "ADC" (blue line) are almost overlapped.

(red line) has a powerful effect on the funded ratio. Once that cap is removed, both alternative approaches (the green and blue lines, which are virtually identical) have a near-zero probability of resulting in a deeply underfunded plan.[15] The cap protects the University of California from having to make large contributions, but in doing so increases the risk that the funded ratio of UCRP will become very low.

Each panel of Figure 4 shows the median funded ratio, 25th percentile, and 75th percentile for one of the three approaches: the leftmost panel is the current policy and practice, the middle panel removes the 14 percent cap but retains the 8 percent floor, and the rightmost panel removes the 8 percent floor as well (it is the unfettered actuarially determined contribution). As we move from right to left, the figure shows that instituting a contribution floor (middle panel) can lead to large overfunding, while instituting a cap, even with a floor (left panel), can lead to substantial underfunding:

■ The leftmost panel shows that under the current funding practice, in 25 percent of the simulations the funded ratio will drop to about 40 percent or lower by 2044, while in another 25 percent of simulations, the funded ratio will rise to about 160 percent or higher. In the other 50 percent of simulations, the 2044 funded ratio will fall between these values.

- The middle panel shows that with the cap removed, even in the bottom 25 percent of simulations the funded ratio will generally rise over time. In the top 25 percent of simulations, the funding ratio will rise dramatically, reaching well over 160 percent. This occurs in part because, with the 8 percent floor in place, contributions cannot drop below 8 percent even when the plan is substantially overfunded.

- The rightmost panel shows that when the 8 percent floor is removed the plan is much less likely to experience runaway overfunding. Although contributing the ADC narrows considerably the range of likely funded-ratio outcomes after thirty years, that range is still quite broad: the 25th percentile results in a funded ratio of approximately 85 percent while the 75th percentile results in a funded ratio of approximately 160 percent.

Figure 4. Caps and Floors on Contributions Greatly Expand the Likely Range of the Funded Ratio

Distribution of funded ratios across simulations under different funding approaches
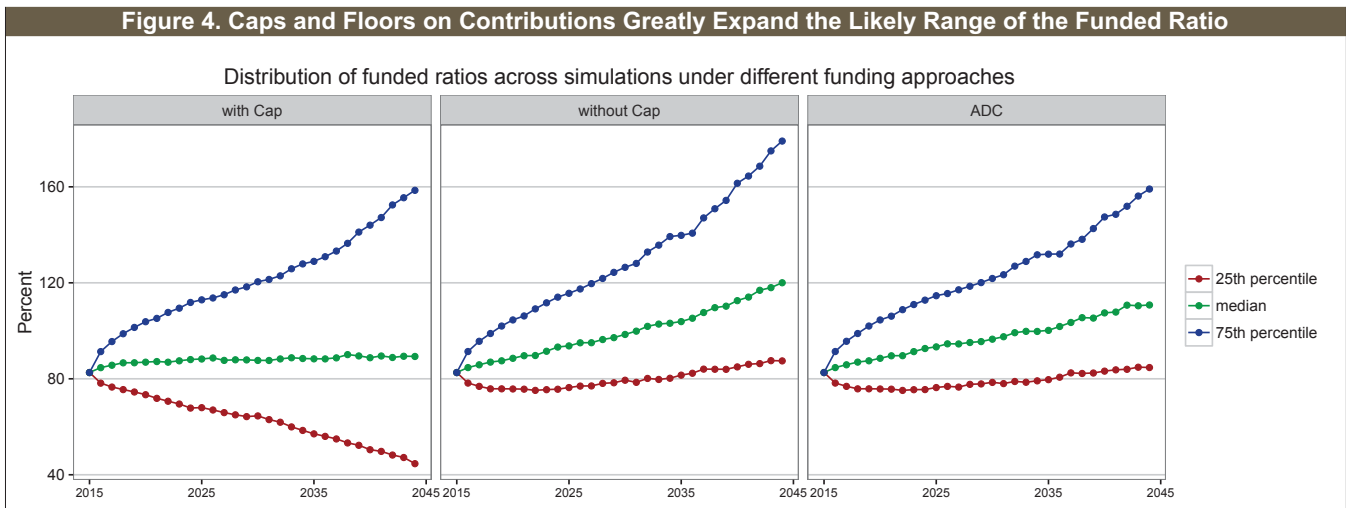
The uncapped contribution polices eliminate the risk of severe underfunding at the expense of greatly increasing the risk of sharp increases in contributions, while the contribution cap protects the University from swings in contributions. Figure 5 shows the risk of large increases in employer contributions over short periods of time. Each point shows the probability that the employer contribution rose by more than 10 percent of payroll in any previous consecutive five-year period. For example, the probability at 2025 is almost 20 percent under both uncapped approaches. This means that there is a nearly 20 percent chance that employer contributions will have increased by more than 10 percent of payroll in any five previous consecutive years, such as periods from 2015 to 2020, 2016 to 2021, and so on, through 2025 to 2030. By the end of the thirty-year period, there is about a 46 percent chance that contributions will have increased by more than 10 percent of payroll in at least one of those five-year periods under the funding approach without the 14 percent cap but with the 8 percent floor (green line), and about a 57 percent chance under the full-ADC funding approach with neither a cap nor a floor (blue line).

Figure 5. Removing the Cap on Contributions Creates a Substantial Risk That Contributions May Rise by More Than 10 Percent of Payroll in a Short Period of Time

Probability of ERC rising by more than 10% of payroll
in any 5−year period up to the given year
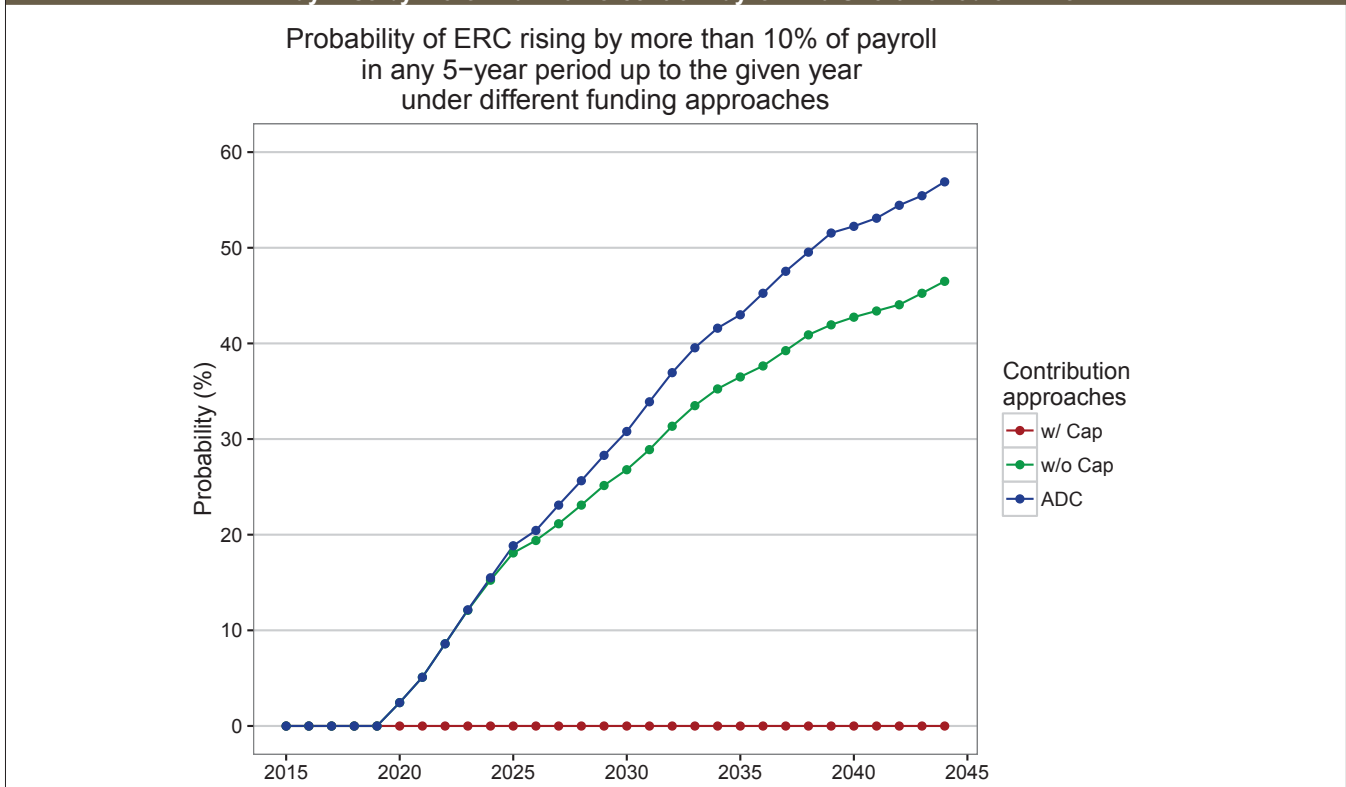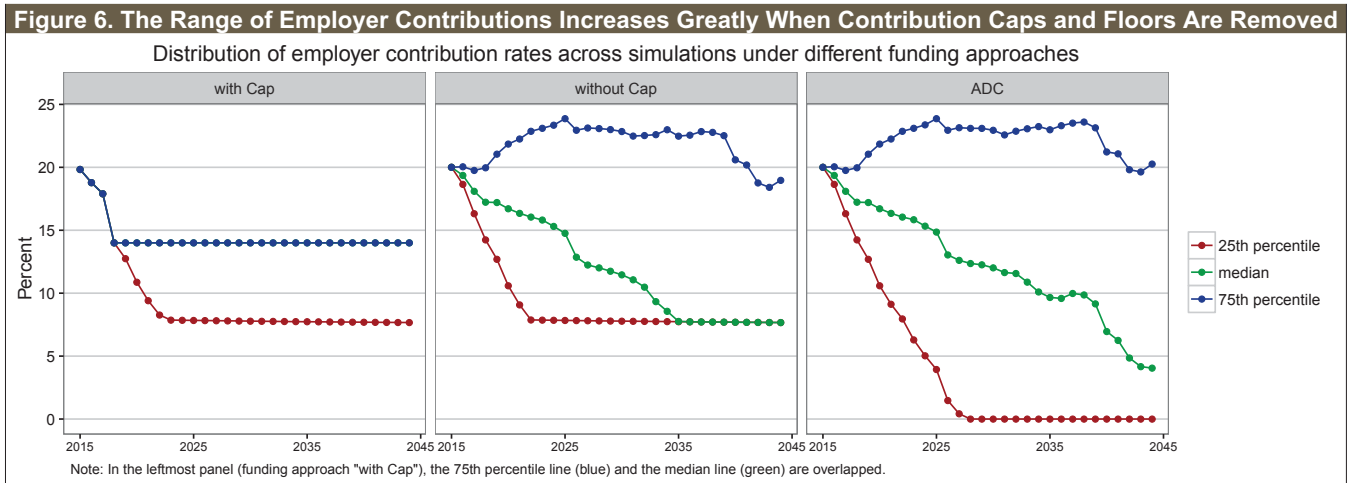under different funding approaches

Figure 6 shows how the likely range of employer contributions is affected by the contribution caps and floors. Each panel shows the median employer contribution rate, as well as the 25th percentile and 75th percentile for one of the three approaches: the leftmost panel is the current policy and practice, the middle panel removes the 14 percent cap but retains the 8 percent floor, and the rightmost panel removes the 8 percent floor as well (it is the unfettered actuarially determined contribution):

- The leftmost panel shows that under the current funding practice, in the median simulation, and all higher percentiles (including the 75th percentile) the employer contribution will be at the 14 percent cap in most years, while in 25 percent of the simulations the employer contribution will be at the 8 percent minimum in most years. As noted earlier, this funding practice protects the University from significant swings in contributions, but as a result the funded ratio can fall to quite low values.

- The middle panel shows that with the cap removed the employer contribution can be quite high, particularly at or above the 75th percentile, where the employer contribution could be at or above 23 percent for many years.

- The rightmost panel shows that when the 8 percent floor is removed, in about a quarter of the scenarios (those with relatively good investment returns), employer contributions can fall to zero and stay there.

Figure 6. The Range of Employer Contributions Increases Greatly When Contribution Caps and Floors Are Removed

Distribution of employer contribution rates across simulations under different funding approaches

Note: In the leftmost panel (funding approach "with Cap"), the 75th percentile line (blue) and the median line (green) are overlapped.

Comparison of Investment Return Scenarios That Begin With Several Years of Low Returns

The previous section examined the scenario in which the investment return is stochastic with an expected return of 7.25 percent every year, consistent with the long-run actuarial assumption. However, the current low-interest-rate environment may make the earnings assumption very difficult to achieve. In this section we compare the base-case scenario 2 with two more-realistic scenarios where the expected compound returns are lower than the assumed return for six years and fifteen years, respectively, and then rise to the currently assumed long-run value.

- Scenario 2 "Assumption achieved: stochastic": 7.25 percent expected compound return base case.

- Scenario 3 "6 years of low returns": six years of low but rising expected returns, gradually increasing from 5 percent to 7.25 percent, followed by 7.25 percent expected compound returns for the remainder of the period, resulting in a compound expected return of 6.9 percent.

- Scenario 4 "15 years of low returns": Fifteen years of low returns, followed by an expected compound return of 7.5 percent. The first ten years have an expected compound return of 4.5 percent, and the next five years have an expected compound return of 6.5 percent. These three separate periods result in an overall compound expected return of 6.4 percent.
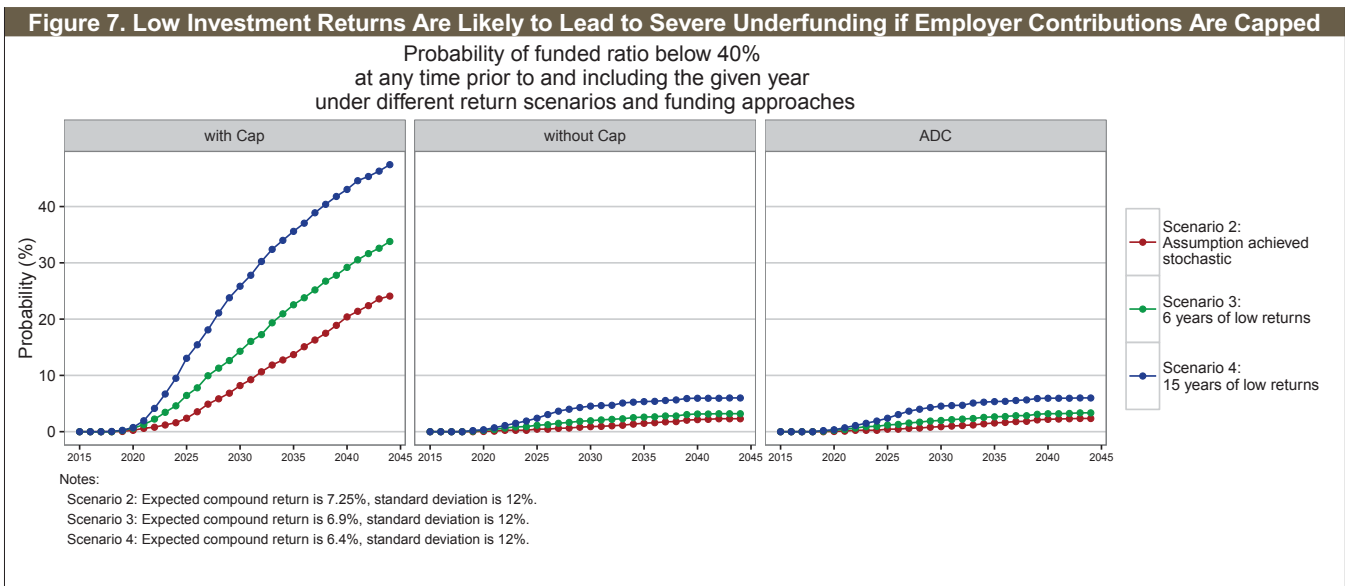
(Refer back to Table 2 for details of investment return scenarios.)

The simulation results show that under the current funding practice with a contribution cap, the risk of severe underfunding rises substantially if expected compound returns are lower than the assumed return in early years, while the two uncapped funding approaches would provide good protection against the risk of severe underfunding even in the lower-return scenarios. Figure 7 shows results for all three stochastic return scenarios, under the three different funding approaches for the first thirty years,

ending in 2044. Each panel shows the probability of the funded ratio falling below 40 percent for the three return scenarios. The left panel shows the current UCRP capped funding practice; the middle panel shows the results with the cap removed but an 8 percent floor still in place; and the right panel shows the impact of removing both cap and floor, which amounts to full payment of the actuarially determined contribution.
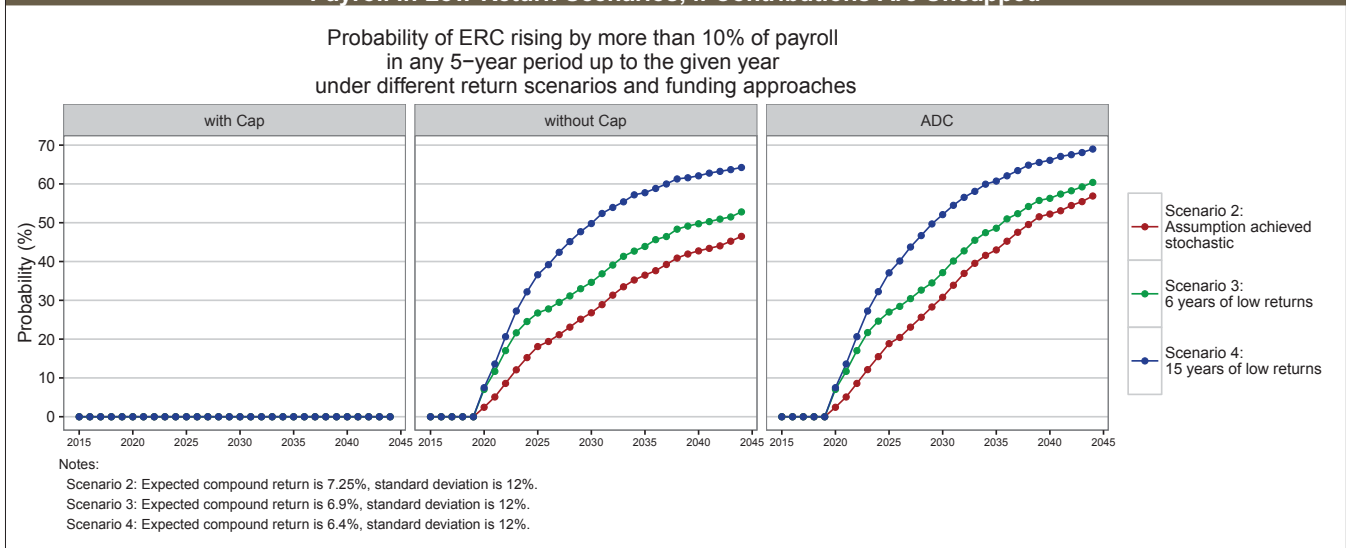
- The left panel, representing current funding practice, shows that the risk of a low funded ratio rises substantially if investment returns are lower, on average, than the assumed average of 7.25 percent. The risk of falling below 40 percent by 2044 is about 24 percent in the scenario 2 base case with an expected return of 7.25 percent (red line). This risk rises to 34 percent for scenario 3 (green line), and to almost 50 percent for scenario 4 (blue line).

- The middle and rightmost panels show that the risk of the funded ratio falling below 40 percent disappears almost completely if the employer 14 percent contribution cap is removed, even when returns fall short of expectations on average. The method the UCRP actuary uses to compute the actuarially determined contribution restores the funded ratio quite rapidly, as long as it is paid, without a cap. The twenty-year amortization period is shorter than the period used by many other pension plans, and the level-dollar closed amortization also helps to restore the funded ratio quickly. For pension plans that use thirty-year level percent amortization — a common approach that leads to much slower improvements in the funded ratio — the risks of a low funded ratio would be greater.

The protection against severe underfunding under the uncapped funding approaches comes at a cost of much higher risk of

Figure 7. Low Investment Returns Are Likely to Lead to Severe Underfunding if Employer Contributions Are Capped

Probability of funded ratio below 40%
at any time prior to and including the given year
under different return scenarios and funding approaches

Notes:
  Scenario 2: Expected compound return is 7.25%, standard deviation is 12%.
  Scenario 3: Expected compound return is 6.9%, standard deviation is 12%.
  Scenario 4: Expected compound return is 6.4%, standard deviation is 12%.

large increases in employer contributions in a short time period. Figure 8 shows the probability of the employer contribution rising by more than 10 percent of payroll in any five-year period. The three panels represent funding approaches and the three lines represent investment return scenarios in the same way as in Figure 7. Under the current funding approach, there is no risk that the employer contribution will rise by more than 10 percent in a five-year period. Under the two uncapped approaches there is substantial risk that the employer contribution will rise by more than 10 percent of payroll in some five-year period — a more than 60 percent probability, by year thirty, in investment return scenario 4. The risk of sharp rises in short periods is greater in the rightmost panel, which does not have the 8 percent minimum contribution, which is not surprising.

Figure 8. There is a Significant Chance That Contributions Will Rise By More Than 10 Percent of Payroll in Low-Return Scenarios, if Contributions Are Uncapped

Probability of ERC rising by more than 10% of payroll
in any 5−year period up to the given year
under different return scenarios and funding approaches

Notes:
Scenario 2: Expected compound return is 7.25%, standard deviation is 12%.
Scenario 3: Expected compound return is 6.9%, standard deviation is 12%.
Scenario 4: Expected compound return is 6.4%, standard deviation is 12%.

Comparison of Investment Return Scenarios With Alternative Return-Volatility Profiles

The stochastic return scenarios we examined in previous sections are constructed so that their return-volatility profiles are similar to other stochastic studies we have reviewed. While these hypothetical scenarios can demonstrate the interplay between the return-volatility profiles and funding approaches, they are not necessarily consistent with the current capital assumptions. In this section we compare the base case to two scenarios with alternative return-volatility profiles constructed based on publicly available capital market assumptions.

- Scenario 2 "Assumption achieved: stochastic": 7.25 percent expected compound return base case.

- Scenario 5 "High volatility reflecting market forecasts": 7.25 percent expected compound return and standard deviation of 16 percent. This scenario is based on our review

of investment return analyses performed elsewhere. This scenario shows that the earnings assumption of 7.25 percent requires greater risk-taking than our base-case scenario suggests.
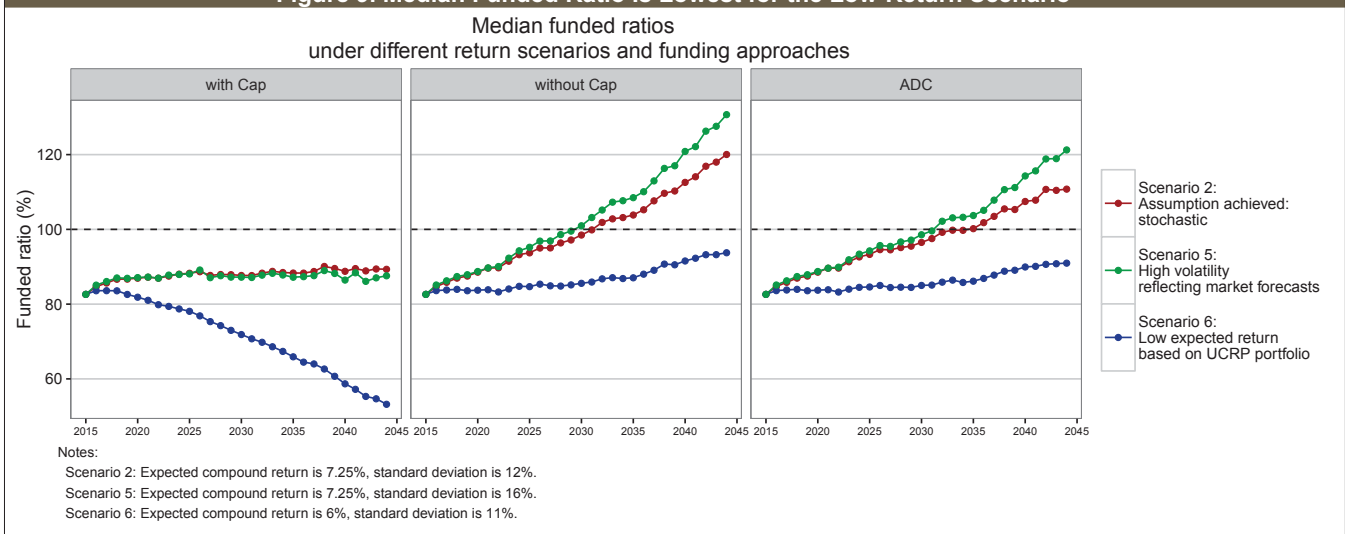
- Scenario 6 "Low expected return based on UCRP portfolio": 6 percent expected compound return and standard deviation of 11 percent. This scenario is based on the current UCRP portfolio and a publicly available set of market assumptions. This scenario suggests that the earnings assumption is too optimistic compared to what the UCRP portfolio can actually expect to achieve in the current market environment.

(Refer back to Table 2 for details of investment return scenarios.)

In the lower-investment-return scenario 6, it is more difficult for the plan to achieve full funding than in the other two scenarios where the earnings assumption is met on average, but the plan still has little exposure to the risk of severe underfunding as long as the contribution is not capped. In the high-volatility scenario 5, the plan faces substantially higher risk of severe underfunding under the uncapped funding approaches than under the other two scenarios with lower volatility.

Figure 9 shows the median funded ratio of return scenarios 2, 5, and 6, which have different expected compound returns or standard deviations, as noted in the figure. Under the current funding practice with the employer contribution cap (leftmost graph), the median funded ratio increases slowly to around 90 percent in the thirty-year period in the two return scenarios with a 7.25 percent mean compound return (red and green lines). In scenario 6, where the expected compound return of 6 percent is well below the assumed return of 7.25 percent, it is not surprising to see that the median funded ratio drops substantially to around 50 percent by year thirty (blue line). Under the two funding

Figure 9. Median Funded Ratio Is Lowest for the Low-Return Scenario

Median funded ratios
under different return scenarios and funding approaches

Notes:
   Scenario 2: Expected compound return is 7.25%, standard deviation is 12%.
   Scenario 5: Expected compound return is 7.25%, standard deviation is 16%.
   Scenario 6: Expected compound return is 6%, standard deviation is 11%.

approaches without the employer contribution cap (middle and rightmost graphs), the median funded ratio will rise dramatically and reach overfunding well before year thirty in scenarios 2 and 5 where on average the 7.25 percent return assumption is met. For scenario 6, with a 6 percent expected compound return, the median funded ratio rises slowly toward 100 percent but still fails to reach full funding by the end of year thirty, despite payment of actuarially determined contributions, or more, in all years.

Figure 10 shows the probability of the funded ratio falling below 40 percent for the three investment-return scenarios under the three funding approaches. Although scenarios 2 and 5, with a 7.25 percent expected compound return, have a similar median funded ratio as shown above, scenario 5 has much greater risk of severe underfunding due to its higher investment-return volatility. In fact, scenario 5 has greater risk of severe underfunding than even scenario 6, which has a lower expected return but also lower volatility, under the uncapped contribution approaches.

Both the high-volatility scenario 5 and the lower-return lower-volatility scenario 6 will lead to higher risk of large contribution increases in short time periods compared to the base-case scenario 2. The median employer contributions are much higher in the lower-return lower-volatility scenario 6 than in the other two scenarios.

Figure 10. Probability of Severe Underfunding Is Generally Greatest When Investment-Return Volatility is High

Probability of funded ratios below 40%
at any time prior to and including the given year
under different return scenarios and funding approaches

Notes:
Scenario 2: Expected compound return is 7.25%, standard deviation is 12%.
Scenario 5: Expected compound return is 7.25%, standard deviation is 16%.
Scenario 6: Expected compound return is 6%, standard deviation is 11%.
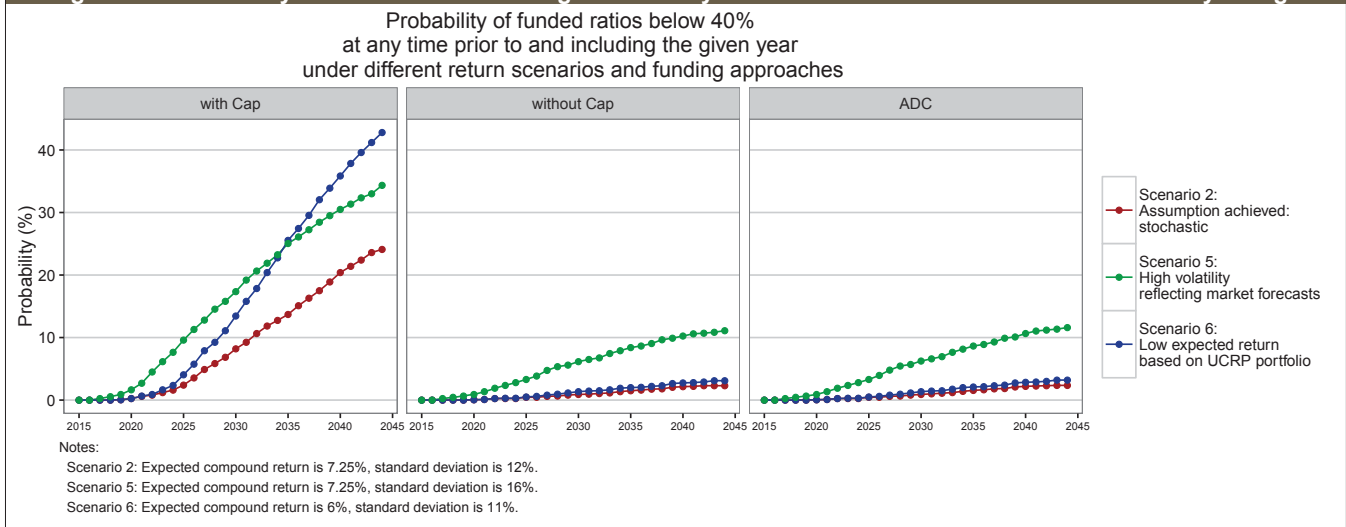
Figure 11 presents the median employer contribution of the three investment return scenarios under different contribution approaches. Under the current contribution approach (leftmost graph), the median employer contributions are the same in all three investment-return scenarios because the 14 percent cap on employer contribution is always binding. Under the two uncapped contribution approaches (middle and rightmost graphs), low-investment-return scenario 6 has a much higher median employer contribution than the higher-return, higher-volatility

investment scenario 5. In scenario 6, the expected compound return of 6 percent falls far short of the assumed return of 7.25 percent, and a higher employer contribution on average is required to make up the shortfall.

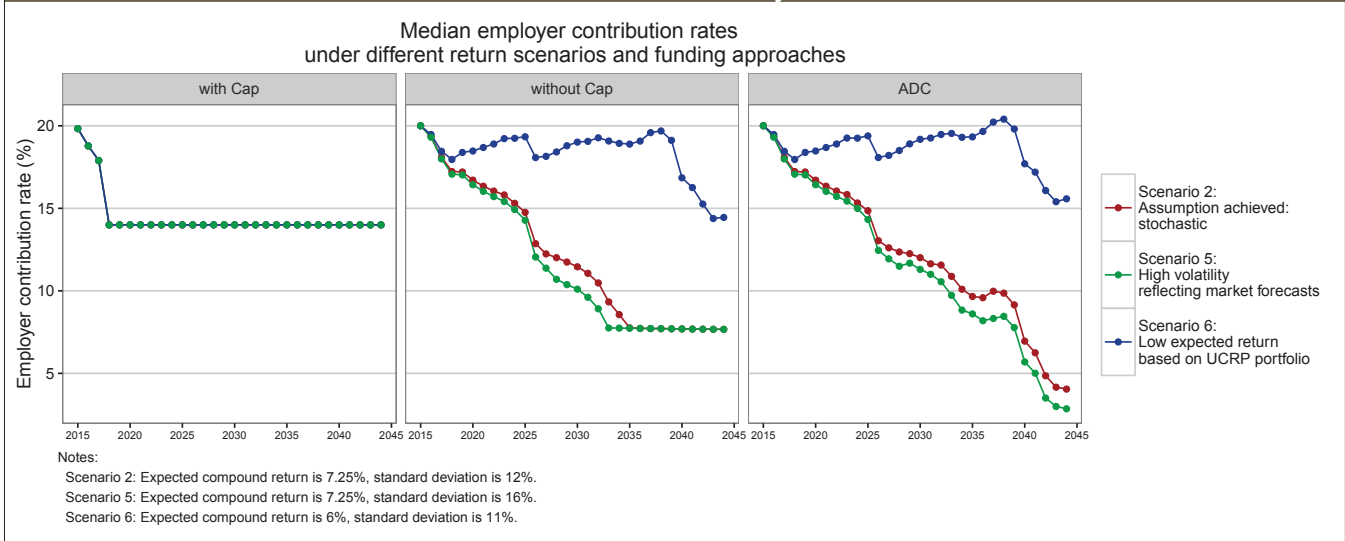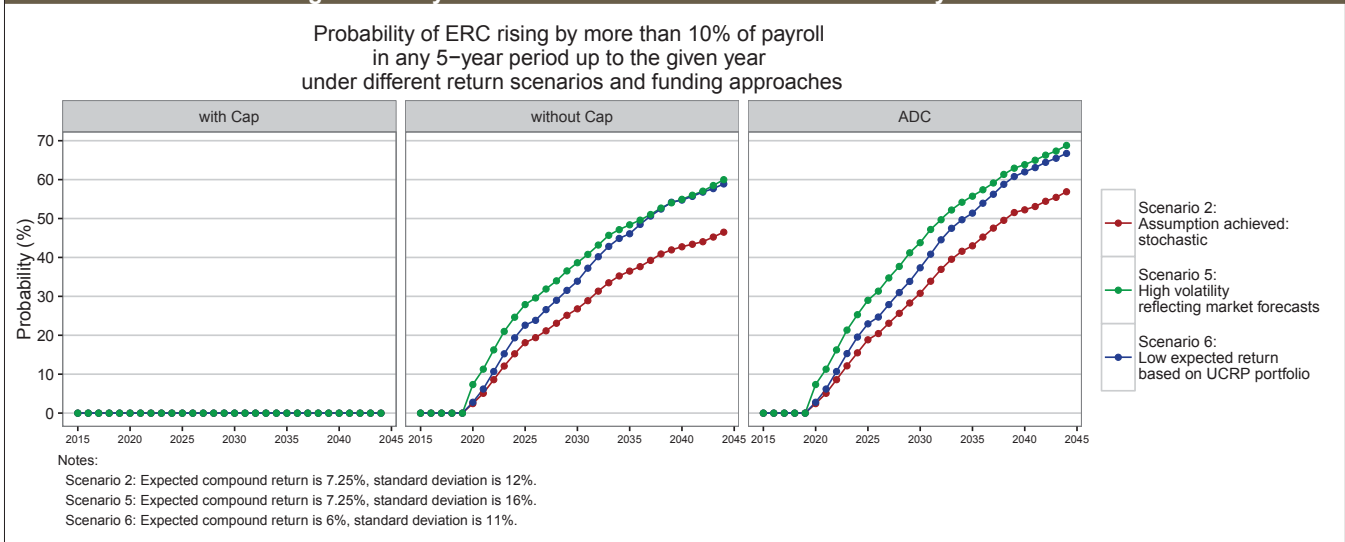**Figure 11. Median Employer Contribution as a Percentage of Payroll Is Highest in the Lower-Return Lower-Volatility Scenario**

Median employer contribution rates
under different return scenarios and funding approaches

Notes:
Scenario 2: Expected compound return is 7.25%, standard deviation is 12%.
Scenario 5: Expected compound return is 7.25%, standard deviation is 16%.
Scenario 6: Expected compound return is 6%, standard deviation is 11%.

Figure 12 shows the probability of the employer contribution rising by 10 percent of payroll in any consecutive five-year period over the next thirty years. Under the current contribution approach, the cap on employer contributions allows no risk that the employer contribution will rise by more than 10 percent in a five-year period. Under the two uncapped contribution approaches, the risk of a sharp increase in employer contribution is substantially higher in high-volatility scenario 5 and lower-

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Figure 12. The Risk of Large Contribution Increase in a Short Time Period Is Higher in the High-Volatility Scenario and the Low-Return Low-Volatility Scenario

Probability of ERC rising by more than 10% of payroll
in any 5−year period up to the given year
under different return scenarios and funding approaches

Notes:
Scenario 2: Expected compound return is 7.25%, standard deviation is 12%.
Scenario 5: Expected compound return is 7.25%, standard deviation is 16%.
Scenario 6: Expected compound return is 6%, standard deviation is 11%.

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volatility lower-return scenario 6 than in the base-case scenario. Under these two investment return scenarios there is a 60 percent or greater chance that the employer contribution will rise by more than 10 percent of payroll in a consecutive five-year period in the next thirty years. If either of these return scenarios, which are based on publicly available capital markets analyses, reflect likely market conditions, there is considerable risk that employer contributions will rise substantially.

Summary of Results

Table 4 summarizes results as of 2044 (year 30), for the three funding approaches and the five investment return scenarios. The first column describes the measure that appears in each row. The next five columns show the five stochastic return scenarios under current funding practice. The next five columns do the same for the current approach with the 14 percent employer contribution cap removed, but the approximately 8 percent floor (based on employee contributions) still in place. The final five columns remove the floor as well, so that full actuarially determined contributions are paid.

The table shows the clear trade-off between protecting the fund and protecting the sponsor. The current UCRP funding approach, with its 14 percent cap on employer contributions, protects the sponsor well. As a consequence, we see in the first five columns that the risk of employer contributions rising substantially under any of the five investment return scenarios is minimal. However, the trade-off is substantial funding risk: a 24 percent chance of having the funded ratio fall below 40 percent by year thirty even if the assumed return of 7.25 percent is correct on average. The risk of falling below 40 percent funded rises to over 40 percent if the 7.25 percent earnings assumption is too optimistic and if it is more plausible to expect lower returns as in scenario 4 and scenario 6, in which the expected compound returns are 6.4 percent and 6 percent, respectively. If higher return volatility measured by a standard deviation of 16 percent in scenario 5 reflects the likely market conditions, the probability of the funded ratio falling below 40 percent will be 34 percent, which is almost half again as large as the risk in scenario 2, which has the same expected compound return of 7.25 percent but a lower investment-return volatility (a 12 percent standard deviation).

If the employer contribution cap is removed, as is done in the other two funding approaches we examined (moving rightward in the table), the risk of a low funded ratio is substantially reduced, in large part because of the aggressive pay-down features of UCRP's actuarially determined contribution method, which uses a closed twenty-year amortization period (shorter than used by many pension plans), and level-dollar amortization that pays liabilities down more quickly than the more-common level-percent-of-payroll method. The trade-off is that the risk of the

Table 4. Summary of Results

Risk evaluation measures for selected funding policies and investment return scenarios

All scenarios are stochastic

Probability as of year 30 (2044) that:	UCRP Current employer contribution policy: Cap of 14% and floor of approximately 8%					Employer contribution policy: Cap removed, but 8% floor remains					Employer contribution policy: No cap or floor (pay actuarially determined contribution)				
	Investment return scenarios					*Investment return scenarios*					*Investment return scenarios*				
	Scenario 2 (Assumption achieved: stochastic)	Scenario 3 (6 years of low returns)	Scenario 4 (15 years of low returns)	Scenario 5 (High volatility reflecting market forecasts)	Scenario 6 (Low expected return based on UCRP portfolio)	Scenario 2 (Assumption achieved: stochastic)	Scenario 3 (6 years of low returns)	Scenario 4 (15 years of low returns)	Scenario 5 (High volatility reflecting market forecasts)	Scenario 6 (Low expected return based on UCRP portfolio)	Scenario 2 (Assumption achieved: stochastic)	Scenario 3 (6 years of low returns)	Scenario 4 (15 years of low returns)	Scenario 5 (High volatility reflecting market forecasts)	Scenario 6 (Low expected return based on UCRP portfolio)
Funded ratio falls below 40% in at least 1 year	24.1	33.8	47.5	34.4	42.8	2.3	3.2	6.0	11.1	3.1	2.4	3.4	6.0	11.6	3.2
Employer contribution (ERC) rises by at least 10 percentage points in at least 1 consecutive 5-year period	0.0	0.0	0.0	0.0	0.0	46.5	52.8	64.3	60.0	58.9	56.9	60.4	69.0	68.8	66.8

Notes on return scenarios:
Scenario 2(Assumption achieved: stochastic): Constant expected return over 30 years. Expected compound return is 7.25%, consistent with actuarial assumption of 7.25%.
Scenario 3 (6 years of low returns): Expected returns gradually rise from 5% to 7.25% over years 1-7, then remain at 7.25%; 30-year compound return is 6.9%
Scenario 4 (15 years of low returns): Expected returns are 4.5% in years 1-10, 6.5% in years 11-15, and 7.5% in years 16-30; compound return is 6.4%
Scenario 5 (High volatility reflecting market forecasts): Constant expected return over 30 years. Expected compound return is 7.25%, consistent with actuarial assumption of 16%.
Scenario 6 (Low expected returns based on UCRP portfolio): Constant expected return over 30 years. Expected compound return is 6%, consistent with actuarial assumption of 11%.

employer having to pay much higher contributions is greatly increased.

Conclusions

We draw several conclusions from our analysis:

- If assumed investment returns are achieved each and every year, the plan will move toward full funding with contribution amounts as expected.

- Realistically, even if assumed returns are achieved on average in a single simulation, investment returns will vary significantly from year to year, potentially leading to years of substantial underfunding even in simulations in which, after thirty years, investment returns exceed assumed returns. In simulations in which the assumed return is not achieved over thirty years, volatility can be greater and outcomes worse.

- If assumed returns are correct on average over the long run, but have a 12 percent standard deviation, then under current funding practice with employer contributions capped at 14 percent of payroll:

  - There is a nearly one in four chance that the *funded ratio* will fall below 40 percent — what we consider to be crisis territory — sometime between now and year thirty.

  - *Employer contributions* remain stable and relatively low because of the current 14 percent cap.

- Under the same investment assumptions, if the employer does not cap contributions at 14 percent:

  - There is only about a 2 percent chance of the *funded ratio* falling below 40 percent.

  - There is almost a one in two chance that employer contributions will increase by more than 10 percent of payroll within a consecutive five-year period. With no contribution cap, the employer bears the risk of investment shortfalls, through higher contributions, that currently is borne by the plan.

- Under the alternative investment return scenarios, which generally have either lower expected returns or greater investment return volatility:

  - There is a more than one in three chance that the *funded ratio* will fall below 40 percent in the next thirty years, if the practice of capping employer contributions at 14 percent of payroll is maintained.

  - If the practice of capping contributions is eliminated, the chance of the *funded ratio* falling below 40 percent falls significantly, while there is about a 50 to 70 percent probability that the *employer contribution* will rise sharply, increasing by more than 10 percent of

payroll in at least one consecutive five-year period over the next thirty years, depending on the specific alternative funding approach and on how much lower than 7.25 percent expected returns are.

These simulations suggest that there is considerable risk to UCRP funding if the plan's investment-return assumptions are correct on average over the long run and it maintains the practice of capping employer contributions at 14 percent of payroll. Under plausible alternative investment return assumptions, the risks are greater still. To reduce these risks to plan funding, the University may wish to adjust its contribution policy to allow greater responsiveness to investment results; other plans with rigid contribution policies and practices may wish to do the same. In addition, the fund may wish to examine its risk profile carefully, with an eye toward reducing investment return volatility. Doing so would require higher employer contributions, but would lead to more secure funding of benefits. Many other plans are in a similar situation and should consider their risk profiles carefully as well.

Appendices

Illustration of Individual Stochastic Simulations

Examining individual simulations can help explain what is happening in the model, for individuals not familiar with stochastic simulation. It has the disadvantage that a single simulation could have practically any result imaginable (e.g., returns could be above 20 percent for thirty years in a row or below 5 percent in every year). Thus, it tells us nothing about the likely range of outcomes or what might happen on average.

We illustrate what results in a single simulation could look like by examining four individual simulations (chosen out of 2,000) that have the following characteristics:

- Two simulations achieve the targeted 7.25 percent compound return by year thirty, albeit arriving there by different paths.

- One simulation is better than expected at the end of thirty years, with a compound average of about 8.77 percent, the 75th percentile.

- One simulation is worse than expected at the end of thirty years, with a compound average of about 5.82 percent, the 25th percentile.

We selected these simulations to illustrate the volatility in returns, funded ratios, and contributions when returns are near the middle of the distribution. In fact, fully half of simulations will fall outside of this range (50 percent of the simulations fall between the 25th percentile of 5.82 percent and the 75th percentile of 8.77 percent, with the other 50 percent falling outside this range).

Each of the following four figures has a line for each of these four simulations.

Figure 13 shows the annual investment returns in each of the four simulations. Horizontal lines mark the thirty-year compound return for each line. The figure shows the extreme variability in annual returns. For example, even in the simulation that has a thirty-year compound return of 8.77 percent (green line), well above the 7.25 percent expected return, the annual return is negative in six out of thirty years and the worst year can be as low as -9.94 percent.

Figure 13. Returns in Individual Simulations Are Extremely Variable Over Time, Even When Long-Run Assumption Is Achieved

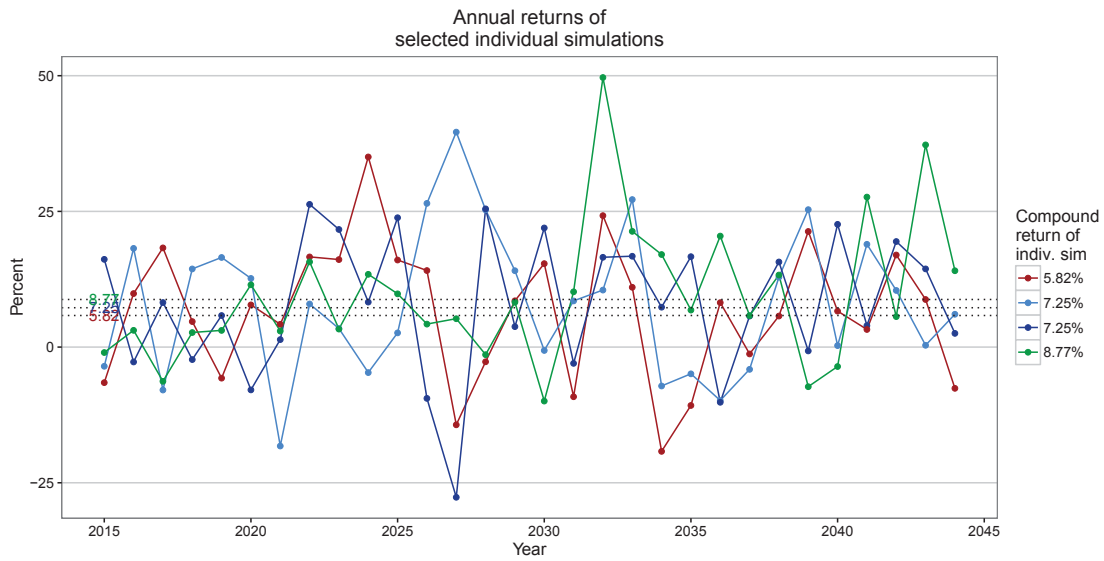Annual returns of
selected individual simulations

Figure 14 shows the rolling compound return for each of the four simulations — each eventually hits its thirty-year average.

Figure 14. Cumulative Compound Returns, Selected Simulations

Rolling geometric returns up to a given year for
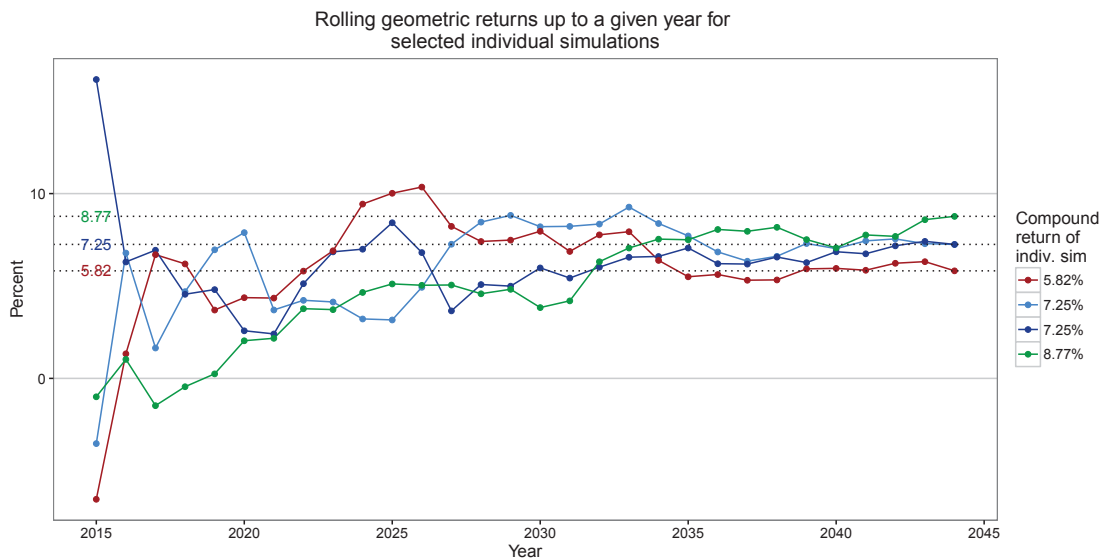selected individual simulations

Figure 15 shows the funded ratio in each year, in each of the four simulations. It's not surprising that the simulation with an 8.77 percent thirty-year compound return (green line) is about 113 percent funded at thirty years. The 5.82 percent simulation (red line), at the 25th percentile, has even achieved a funded ratio as high as 126 percent in year 2027, but the funded ratio declines drastically after that due to a series of very low returns and eventually falls to 65 percent by 2044. Finally, note that even the two simulations with 7.25 percent compound annual return have

Figure 15. Funded Ratios in Individual Simulations Can Diverge Widely
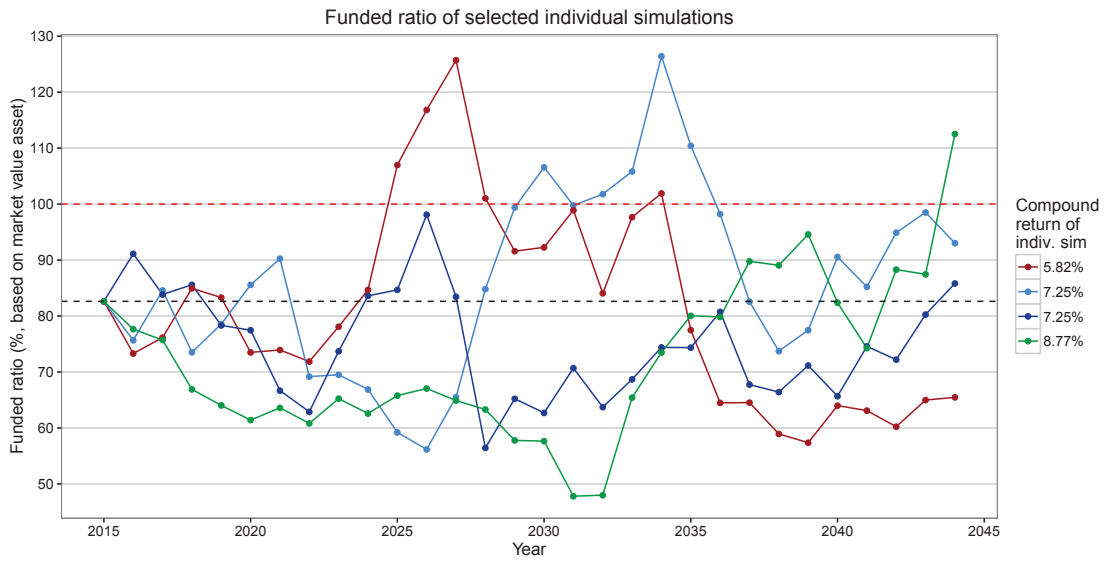
periods in which the funded ratio falls below 60 percent, reflecting the few years of negative and low returns mentioned above.

Figure 16 shows the employer contribution rate for the four simulations. In all four simulations, the employer contribution rates are at the cap most of the time, suggesting that contributions would be much higher if they were uncapped, and that as a result the funded ratio must rise.

Figure 16. Employer Contribution Rate Under Current Funding Practice Does Not Vary Much
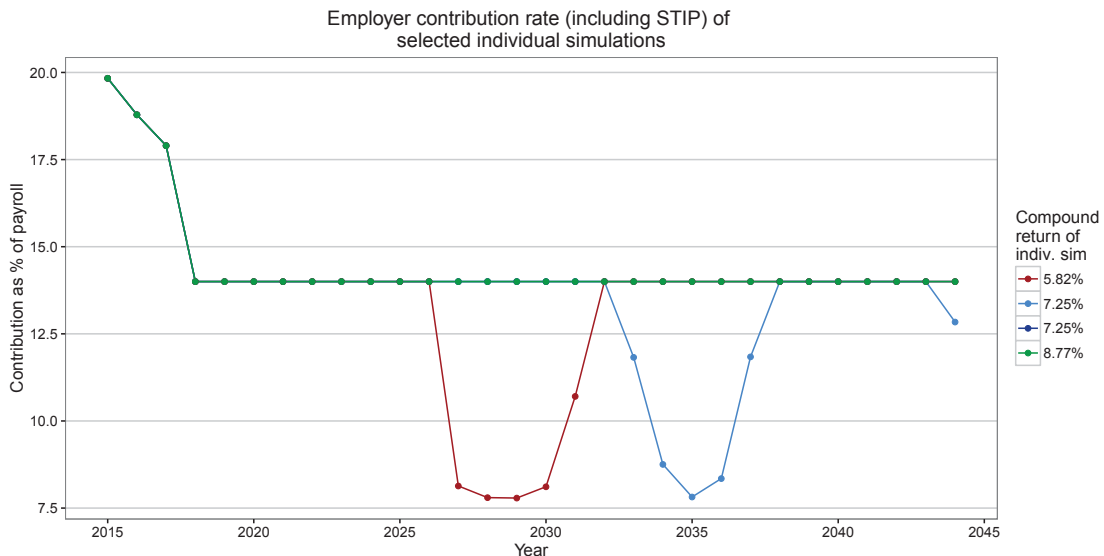
Additional Measures of Risk

Probability That the Funded Ratio Will Rise Above 95 Percent in the First Thirty Years

While our primary focus is on potential bad outcomes, we also examine the probability that the pension fund will become fully funded. For this, we examine the probability that the plan will become 95 percent or more funded in each of the first thirty years. Figure 17 shows this probability for different funding approaches, all under the return scenario with 7.25 percent expected compound return and standard deviation of 12 percent. In year 2044, the chance that the funded ratio will be 95 percent or better is less than 50 percent under the current UCRP capped contribution practice, while the chances are more than 60 percent under the two uncapped funding approaches.

Figure 17. Probability of Near-Full Funding Never Rises Above 50 Percent Under the Current Contribution Practice
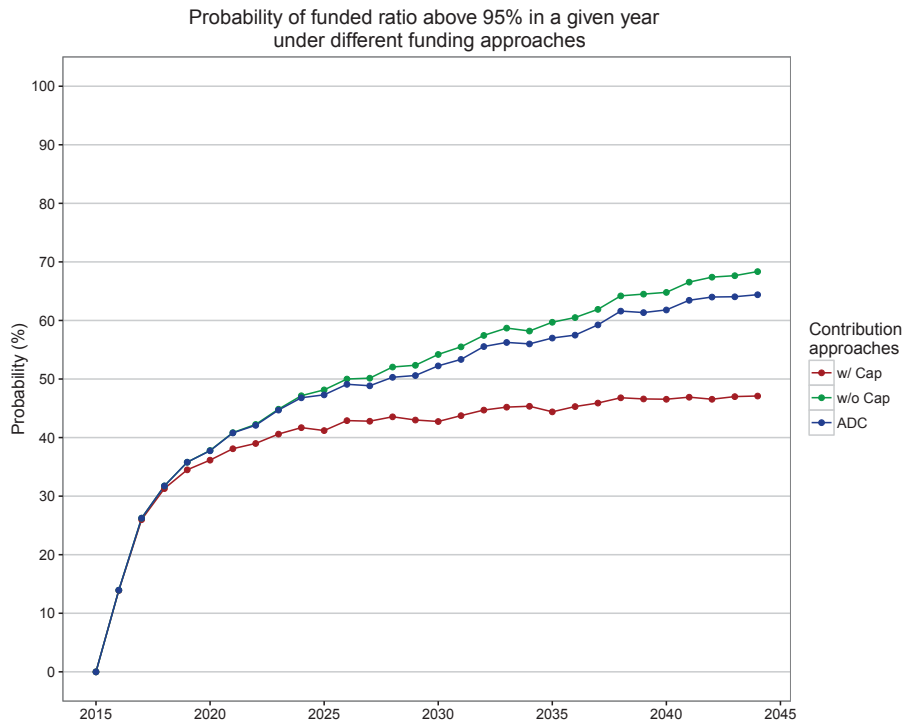
Probability That Employer Contributions Will Rise Above 30 Percent Of Payroll During the First Thirty Years
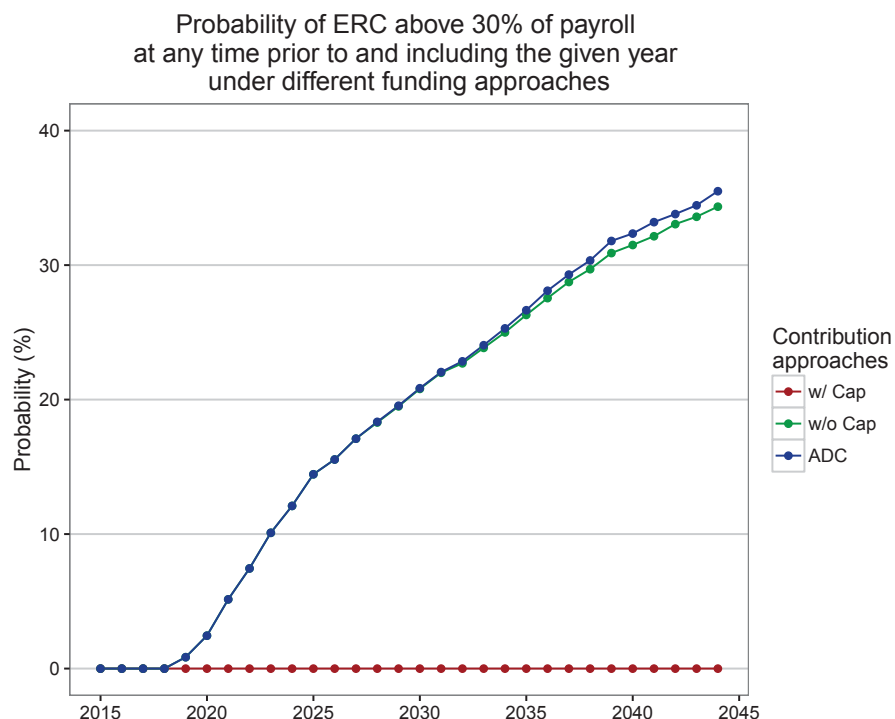
Very high contributions can create great political and financial pressure on plan sponsors and may lead to benefit cuts, tax increases, and crowding out of expenditures on other public services. We use the probability that the employer contribution (including STIP) will rise above 30 percent of payroll as of a given year to evaluate how likely it is that the plan sponsor may face the pressure of high contributions.

This measure will always be zero under the current funding practice of UCRP since the 14 percent cap on employer contributions will protect the plan sponsor from large financial pressure. Under the scenario with the 14 percent cap removed, the plan sponsor is obliged to pay at least the gap between the actuarially determined contribution (ADC) and the employee contribution, which can be very large if the plan experiences an extended period with lower-than-assumed returns. As the time period extends and the chance of a long period of low returns rises, the probability of having a high employer contribution anytime in that period will increase accordingly.

Results Under the 7.25 Percent Expected Compound Return, 12 Percent Standard Deviation Scenario

Figure 18 shows the risk of employer contributions rising above 30 percent of payroll over a thirty-year period. Each point shows the probability that the employer contribution was above 30 percent in any year up to that year. For example, the value at 2026 for both uncapped approaches is about 16 percent. This means that there is a 16 percent chance that employer contributions under either of those approaches will be above 30 percent of payroll in at least one of the years between 2015 and 2026. By the end of the thirty-year period, there is about a 35-36 percent chance that contributions under either of those approaches will have been above 30 percent of payroll at least once in the thirty years. By contrast, there is zero chance that contributions will be

Figure 18. Removing the Cap on Contributions Creates a Significant Risk of Contributions Rising Above 30 Percent of Payroll, When Investment Returns Are Variable
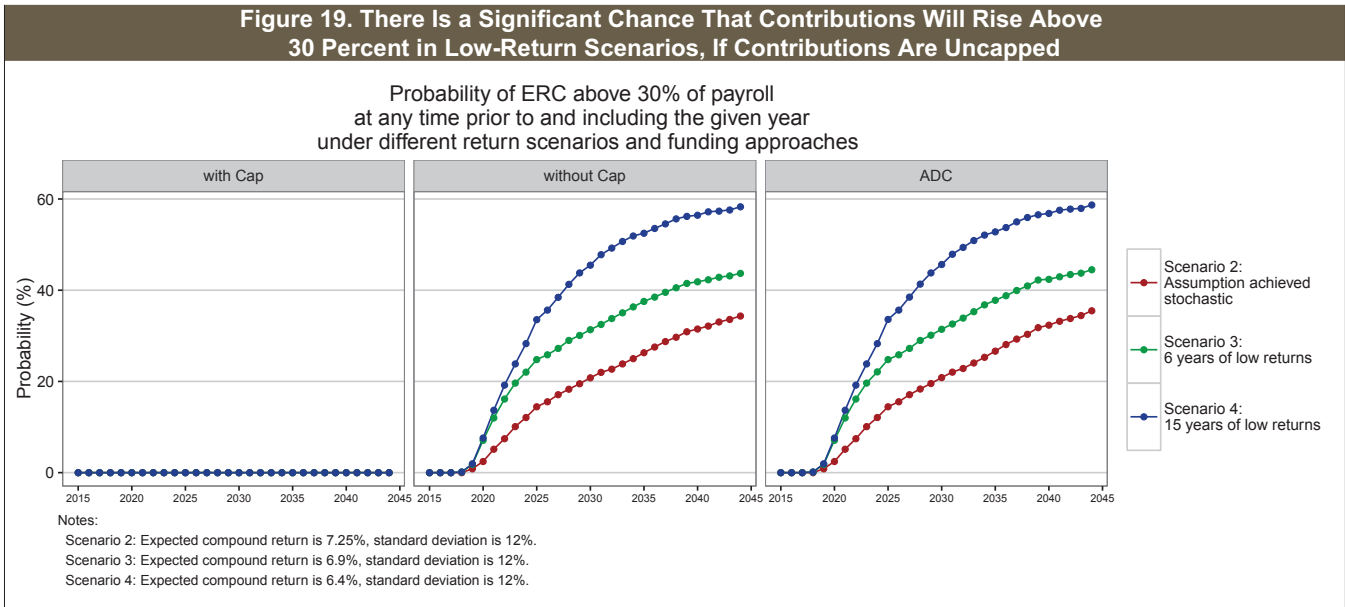

Probability of ERC above 30% of payroll
at any time prior to and including the given year
under different funding approaches

Contribution approaches
- w/ Cap
- w/o Cap
- ADC

above 30 percent of payroll when the 14 percent cap is in place (red line).

Comparisons of Investment Return Scenarios

Figure 19 shows the probability of the employer contribution exceeding 30 percent of payroll. The three panels represent funding approaches and the three lines represent investment return scenarios in the same ways as in Figure 7. The 14 percent cap in the current policy and practice allows no risk that the employer contribution will rise above 30 percent. The two uncapped approaches have substantial risk that the employer contribution will rise above 30 percent — a nearly 60 percent probability, by year thirty, in investment return scenario 4, with fifteen years of low returns resulting in an expected compound return of 6.4 percent. There is very little difference between the two approaches with respect to this risk.

Figure 19. There Is a Significant Chance That Contributions Will Rise Above 30 Percent in Low-Return Scenarios, If Contributions Are Uncapped

Probability of ERC above 30% of payroll
at any time prior to and including the given year
under different return scenarios and funding approaches

Notes:
Scenario 2: Expected compound return is 7.25%, standard deviation is 12%.
Scenario 3: Expected compound return is 6.9%, standard deviation is 12%.
Scenario 4: Expected compound return is 6.4%, standard deviation is 12%.

Comparison of Investment Return Scenarios With Alternative Return-Volatility Profiles

Figure 20 shows the probability of the employer contribution exceeding 30 percent of payroll. Under the current contribution practice, the cap on employer contributions allows no risk that the employer contribution will rise above 30 percent of payroll. Under the two uncapped contribution approaches, both of the risk measures are substantially higher in high-volatility scenario 5 and lower-volatility lower-return scenario 6 than in the base-case scenario. Under these two investment return scenarios there is a 45 to 50 percent probability that the employer contribution will be above 30 percent of payroll by year thirty. If either of these return scenarios, which are based on publicly available capital markets analyses, reflect likely market conditions, there is considerable risk that employer contributions will become quite high.

Figure 20. Probability That the Employer Contribution Rises Above 30 Percent
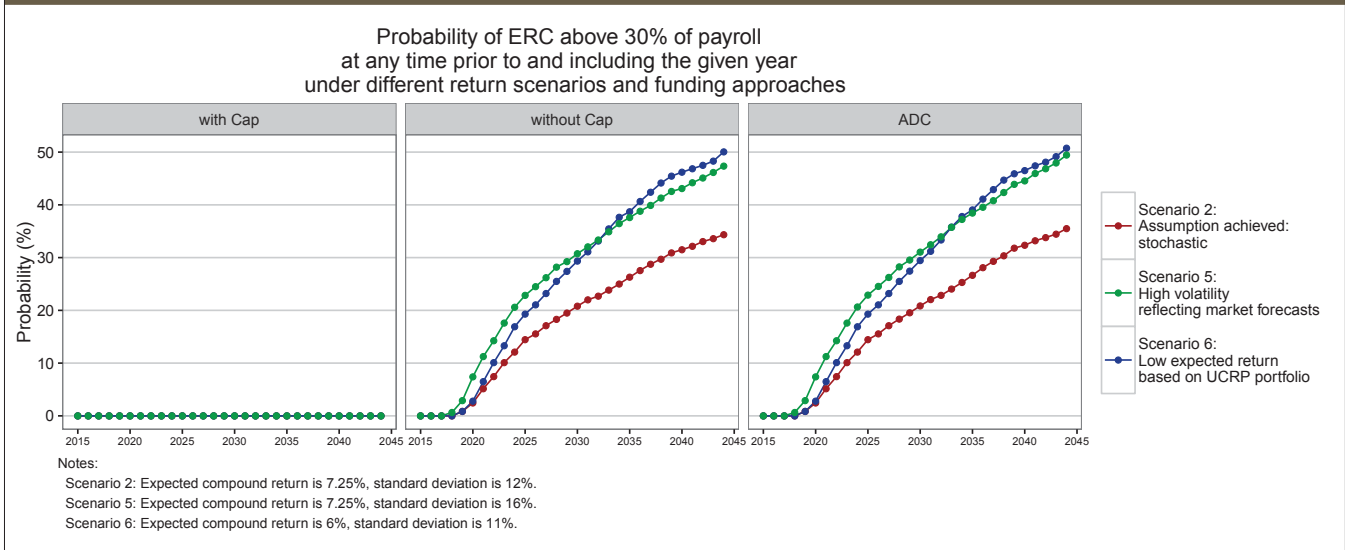
Although the risk measures of high employer contribution and sharp increase in employer contribution are similar in high-volatility scenario 5 and low-volatility low-return scenario 6, they are actually caused by different return-volatility profiles operating in these two scenarios. With the high employer contribution level with a median of near 20 percent of payroll in scenario 6 (see Figure 11), even a moderate volatility of 11 percent standard deviation can lead to a high probability of employer contribution exceeding 30 percent of payroll. In scenario 5, the median employer contribution is much lower since the expected compound return meets the return assumption of 7.25 percent. However, the much higher return volatility of 16 percent in scenario 5 leads to a higher likelihood for simulations with extremely low returns, in which the employer contribution can reach a particularly high level.

Endnotes

1   This scenario is only used for illustrating the variability of investment returns, and is different from the scenarios that are used in our analysis in the following sections.

2   Except where noted, data in this section are from either *University of California Retirement System 14/15 Annual Financial Report* (Oakland: The University of California, October 15, 2015) or from *University of California Retirement Plan Actuarial Valuation Report as of July 1, 2015* (Segal Consulting, October 15, 2015).

3   As reported in the *Annual Financial Report*. Total benefits are approximately $3 billion according to the plan actuary.

4   According to the Public Plans Database (PPD) of the Center for Retirement Research at Boston College, the 75th percentile for the 2014 actuarial-value-of-assets funded ratio of 150 large plans was 82.8 percent. (The market-assets funded ratio is not reported in the PPD.) UCRP's actuarial funded ratio in 2014 was 80.0 percent, according to the 2015 actuarial valuation.

5   The funded ratio was 83.6 percent for total UCRP and 82.6 percent for the campus and medical center segment, which we modeled, both on a market value basis as of July 1, 2015.

6   As reported in the *Annual Financial Report*. When calculated assuming middle-of-year payment, the normal cost is above 18 percent, according to the plan actuary.

7   According to the *Actuarial Valuation Report,* any initial surplus (after a period of underfunding) is amortized over thirty years and changes in surplus are amortized over fifteen years.

8   The unfunded liability existing at the start of the simulation is amortized using assumptions from the *Actuarial Valuation Report*.

9   We assume that a portion of the employer contribution is paid from STIP in first three years: $564 million in year one, $478 million in year two, and $401 million in year three. This is consistent with UCRP expectations.

10   When investment returns are variable, the long-run compound return will be lower than the expected annual return. Thus, we use an annual expected return that is greater than 7.25 percent but is designed to achieve a long-run compound return of 7.25 percent in the average simulation. We calculate the annual expected return via a widely used approximation formula under which the long-run compound return equals the annual expected return minus one half of the annual variance.

11   This is broadly consistent with other estimates of risk associated with public pension plan portfolios. CalPERS has used a 12.96 percent standard deviation, Biggs assumed a 14 percent standard deviation, and Bonafede et al. estimated a 12.5 percent standard deviation. See: *Annual Review of Funding Levels and Risks as of June 30, 2012* (Sacramento: California Public Employees' Retirement System, March 2013), https://www.calpers.ca.gov/docs/forms-publications/annual-review-funding-2012.pdf; Andrew G. Biggs, "The Public Pension Quadrilemma: The Intersection of Investment Risk and Contribution Risk," *Journal of Retirement* 2 (2014): 115–27; Julia K. Bonafede, Steven J. Foresti, and Russell J. Walker. *2015 Report on State Retirement Systems: Funding Levels and Asset Allocation* (Santa Monica: Wilshire Consulting, February 25, 2015), https://www.wilshire.com/media/38890/wilshire_2015_state_funding_report.pdf.

12   It is broadly consistent with, but a bit more optimistic than, assumptions in RVK, *Asset/Liability Study: Los Angeles Fire and Police Pension System* (Portland: RVK, Inc., October 2015). It is quite consistent with assumptions of Callan Associates reported in Timothy W. Martin, "Pension Funds Pile on Risk Just to Get a Reasonable Return," *Wall Street Journal*, May 31, 2016, Markets section, http://www.wsj.com/articles/pension-funds-pile-on-the-risk-just-to-get-a-reasonable-return-1464713013. Callan Associates has noted that it sympathizes with public pension funds given the challenges that professionals face in achieving assumed returns in the current interest rate environment.

13 Based on our analysis of assumptions in *Asset/Liability Study.*

14 For a more detailed discussion on the trade-off between these two kinds of risk, see Donald J. Boyd and Yimeng Yin. *Public Pension Funding Practices: How These Practices Can Lead to Significant Underfunding or Significant Contribution Increases When Plans Invest in Risky Assets*. (Albany: The Nelson A. Rockefeller Institute of Government, June 2016), http://www.rockinst.org/pdf/government_finance/2016-06-02-Pension_Funding_Practices.pdf.

15 The overlapping occurs because removing the contribution floor will only affect funded status in simulations with better-than-expected returns, while funded status in simulations with bad returns, where the funded ratios are more likely to drop below 40 percent, will be largely unaffected.

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