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Pension Liabilities

Fear Tactics and Serious Policy

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Acknowledgments

Introduction

The last two decades have generated substantial demand for accounting techniques that paint a dire picture of government finances. In the early 1990s "generational accounting" showed a lifetime tax burden of 80 or 90 percent for generations yet to be born.[1] After this became discredited,[2] it became popular to express liabilities of programs like Social Security and Medicare over an infinite horizon.[3] These projections could show deficits in hundreds of trillions of dollars. A more modest approach is to calculate the gap between the benefits promised to current beneficiaries and the current and past taxes paid by these beneficiaries.[4] This produces a deficit in the high tens of trillions of dollars. This methodology conceals both that the numbers actually don't seem that large expressed relative to future GDP and that they are driven almost entirely by projections of exploding private-sector health care costs.

These scary numbers are useful for those who want to force cuts to Social Security, Medicare and other social welfare programs. By making the government's financial situation appear far more dire than is actually the case and concealing the extent to which the real problem is the country's health care system, these accounting techniques can make it appear that there is no alternative to substantial cuts in social welfare programs.

The publicity given to the recent spate of papers showing large unfunded liabilities for public pensions must be understood in this context.[5] These papers purport to show unfunded liabilities for these pension funds in the range of $3-4 trillion as opposed to the roughly $1 trillion in unfunded liability reported using the accounting of the funds themselves. The basis for the difference is that these papers discount pension fund liabilities using either the interest rate on corporate bonds or the "risk-free rate of return" on Treasury bonds. These interest rates are considerably below the 7.5-8.0 percent return assumed by pension fund managers, which leads to a much higher calculation of future liabilities.

Three separate issues have been raised in assessing pension liabilities:

1) The appropriate rate of discount to use in attaching a value to these liabilities;
2) The accounting rule that should be used in determining the proper funding level; and
3) The appropriate mix of assets to be held by public pensions.

This paper does not address the first issue. It is standard to use a risk-free rate of return in calculating future liabilities. Arguably this should be used with pension liabilities as well.

The paper does not directly discuss the appropriate mix of assets for pension funds to hold, although it is worth noting that long-lived entities like state and local governments are far better situated than individuals to absorb the timing risk associated with holding equities. Any argument that state and local pension funds should not hold equities would have to address the fact that individual workers do routinely hold equities in their retirement accounts. It would be difficult to

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1 See Auerbach, Gokhale, and Kotlikoff (1991), Kotlikoff (1993), and Auerbach, Gokhale, and Kotlikoff (1995).
2 See Baker (1995) and Congressional Budget Office (1995).
3 See, for example, Gokhale and Smetters (2003).
4 See, for example, Government Accountability Office (2008).
5 See, for example, Novy-Marx and Rauh (2009).

develop a logic whereby individual workers are better situated to bear the timing risk associated with equities than state and local governments.

The focus of this paper is on the second point, the appropriate rule for pension funds to use in assessing their funding situation. This paper argues that pension funds should adopt a funding principle that is consistent with a return on holdings conditional on the state of the market. As will be shown, the expected "conditional rate of return" used in making this assessment will vary depending on the current ratio of stock prices to trend corporate earnings.[6] This funding rule will lead to a more even flow of contributions into the fund than a rule that is based on a fixed return for assets over time.

It is especially important to make this sort of adjustment to expected returns in "bubble" periods where price-to-earnings (PE) ratios in the stock market grow out of line with historic patterns. Such periods virtually guarantee a period of below-normal returns. During such periods, a pension fund that does not adjust its expected returns, and therefore its funding levels, will end up substantially underfunded after the bubble bursts.

This rule also avoids the excessive build-up of funds that would result from applying a risk-free discount rate in a context where pension funds actually earned higher rates of return on average. The bad event resulting from having an underfunded pension is the need to have greater than normal funding – implicitly raising taxes for the governmental unit affected. However, a period of excessive contributions needed to build up reserves to meet a more stringent funding rule also implies higher taxes. It can't make sense to deliberately have a period of higher taxes with certainty in order to avoid the possibility of higher taxes at some point in the future.

An optimal funding rule would maintain a roughly constant ratio of contributions to payouts. If a pension invests in risky assets it will inevitably lead to situations in which the fund has greater or lower than desired levels of reserves, depending on actual market returns. An optimal funding rule would maintain funding in a way that minimizes the frequency and size of the divergences from full funding. Both situations imply greater contributions than necessary: either to build up the surplus or to compensate for the shortfall. If pension fund managers are seeking to avoid an excessive tax burden at a particular point in time, then a surplus or shortfall are both evidence of bad management. The surplus implies bad management because the tax burden was effectively higher than necessary during the period in which the surplus was accumulated and the shortfall implies that taxes will be higher than would have been implied by normal funding in the future.

The rest of this paper describes more carefully a funding rule that discounts future obligations based on a discount rate based on the conditional return on a standard pension portfolio. It uses data on stock and bond returns over the last 135 years to construct simulations comparing the performance of a pension fund that used this funding rule with the performance of a pension fund that determined contributions by discounting by a risk-free rate of return on the same assets.

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6 This funding rule was first described in Weller and Baker (2005). At the time, because of the high price-to-earnings ratios in the stock market, the rule would have implied that pension funds should have used a lower discount rate than the 8.0 percent that they were then employing.

Alternative Pension Funding Rules: Risk-Free Rate of Return versus Economically-Conditional Rate of Return

The simulations in this paper define a pension as being "fully funded" if its current assets are sufficient to cover the next 30 years of projected payouts based on a given discount rate. In keeping with this definition, we apply a rule that regardless of the current funding level, contributions to the pension must be sufficiently large so that in 10 years the pension will be fully funded based on the chosen discount rate. (The appendix provides a full description of the basis for the simulations.)

Suppose that in 2012, we seek to have in 2022 a pension that is fully funded. This means that in 2022 we must have pension assets equal to discounted payouts over 2022-51. By 2022, the pension will have paid out benefits over 2012-21 and collected contributions over the same time. Therefore, the funding *goal* requires that current assets plus discounted contributions over the next ten years must be no less than discounted payouts over 2012-51—that is, the next 40 years.

For a pension that will pay benefits totaling $1 million this year and will increase by 5 percent annually, this calculation is illustrated in **Table 1**. If we assume a 5 percent discount rate, then the pension must have $30 million on hand (column 2) to be considered fully funded—more if a lower discount rate is used, and less if a higher discount rate is used. In 10 years, however, the pension will need to have $48.9 million in assets. At 5 percent interest, we need $30 million today (column 4) to reach that goal. Consequently, all benefits over the next 10 years (column 3) need to be paid without spending any of the initial $30 million. That is, it is necessary to contribute $10 million (column 5) to the pension. With $10 million in contributions and $10 million in payouts, this results in a contribution rate of 100 percent of payouts.

TABLE 1
Computing Contributions To A Fully Funded Pension

Discount Rate (percent)	Initial Assets (millions of $)	Discounted Payouts		Contributions Years 1-10 (millions of $)	Contribution Rate (percent)
		Years 1-10 (millions of $)	Years 11-40 (millions of $)		
(1)	(2)	(3)	(4)	(5) = (3) + (4) - (2)	(6) = (5)/(3)
3	40.2	10.9	48.7	19.4	178
5	30.0	10.0	30.0	10.0	100
8	20.5	8.8	15.5	3.8	43

Now suppose that we assume an 8 percent discount rate. Because we are more heavily discounting the future, we need only $20.5 million today to be fully funded. In ten years, we will need $33.5 million in assets, but because we are imputing a higher rate of interest, we need today only set aside $15.5 million to reach that goal. This leaves $5 million, which may be used to pay benefits over the next 10 years. At our 8 percent discount rate, we need $8.8 million today to pay these benefits, leaving us $3.8 million shy. If we make pension contributions equal to 43 percent of each year's payouts, then the pension will still be fully funded in 10 years.

Similarly, a much lower discount rate will require greater initial resources to be fully funded, and also require larger contributions. This would make it appear that a higher discount rate is preferable, but only because we have simply assumed a higher return on assets.

In Table 1, we assumed for simplicity that the actual return on assets equaled the chosen discount rate. In the real world-- though the pension manager chooses the discount rate-- the market determines the actual return on pension assets. Thus, we wish to separate the effect of the choice of discount rate from the actual return on assets. In **Table 2**, we see the results after one year, assuming the mix of assets in each case is exactly the same and in every case produces the same 5 percent return.

TABLE 2
First Year Fully-Funded Pension Performance with 5% Market Return and Selected Discount Rates

Discount Rate (percent)	Initial Assets (millions of $)	Payouts (millions of $)	Contributions (millions of $)	5% Market Return on Assets (millions of $)	Assets at End of Year (millions of $)	Full Funding in Start of Next Year (millions of $)
3	40.2	1.0	1.8	2.0	43.0	42.2
5	30.0	1.0	1.0	1.5	31.5	31.5
8	20.5	1.0	0.4	1.0	21.0	21.6

As can be seen in Table 2, actual performance that is higher than the selected discount rate results in an overfunding of the pension, while lower market performance leads to underfunding. These funding issues may become chronic, with contribution rates falling over time. With higher performance the pension may become effectively fully pre-funded, paying for all future benefits out of interest alone. It is hard to imagine it good policy to take money from workers today to fund the retirements of future workers who will enjoy higher real incomes.

While the selection of a lower discount rate may help prevent underfunding, a fully pre-funded pension with a low discount rate will suffer correspondingly larger losses in a bear market and may necessitate even greater contributions to rebuild those assets.

Conversely, in **Table 3** we see the contribution rates needed in response to an initial underfunding of 20 percent based on various discount rates. At a 5 percent discount rate, the 20 percent shortfall raises the first-year contributions from $1 million to $1.6 million. While this jump in contributions may be undesirable, it is still less than the $1.78 million (Table 1) that would be required for a pension fully funded under a 3 percent discount rate.

TABLE 3
Pension Contributions Required to Correct 20% Underfunding at Selected Discount Rates

Discount Rate (percent)	Initial Assets (millions of $)	Discounted Payouts Years 1-10 (millions of $)	Discounted Payouts Years 11-40 (millions of $)	Contributions Years 1-10 (millions of $)	Contribution Rate (percent)
(1)	(2)	(3)	(4)	(5) = (3) + (4) - (2)	(6) = (5)/(3)
3	32.2	10.9	48.7	27.5	252
5	24.0	10.0	30.0	16.0	160
8	16.4	8.8	15.5	7.9	89

Finally, even if a bear market never comes, shifting from a higher to lower discount rate requires the immediate building-up of assets. Suppose we wish to protect ourselves against a future situation in which the pension is only 80 percent funded at a 5 percent discount rate—i.e., when we would want to have $30 million, but find only $24 million on hand. If, in order to avoid that future $6 million shortfall, we lowered the discount rate to 3 percent *today*, this would result in an immediate *$10.2*

million shortfall. **Table 4** shows the required contribution rates that result from raising or lowering the discount rate.

TABLE 4
Pension Contributions Required to Achieve Full Funding at Selected Discount Rates

		Discounted Payouts		Contributions	Contribution
Discount Rate	Initial Assets	Years 1-10	Years 11-40	Years 1-10	Rate
(percent)	(millions of $)	(millions of $)	(millions of $)	(millions of $)	(percent)
(1)	(2)	(3)	(4)	(5) = (3) + (4) - (2)	(6) = (5)/(3)
3	30.0	10.9	48.7	29.6	271
5	30.0	10.0	30.0	10.0	100
8	30.0	8.8	15.5	--*	--*

* No contributions are required in this scenario.

## Addressing the Real Risk of Shortfalls

Lowering the discount rate is a strange policy choice that avoids possible large future contributions by insisting on large contributions today. But the greatest risk of adverse market outcomes does not come from a collapse in the price of a fairly-valued asset temporarily becoming undervalued. Rather, downside risk comes primarily from the collapse in the price of an overvalued asset when suddenly valued according to fundamentals.

In the housing bubble of the 2000s, there was a prevailing insistence that housing prices could not fall. Lenders encouraged borrowers to leverage up on the assumption that prices would continue to rise even as rents stayed low, implying an ever-higher sales price-to-rent ratio. Similarly, in the stock bubble of the 1990s, there was remarkable insistence that equities would produce historical rates of return no matter how expensive stocks became in relation to the earnings the companies had any hope of distributing in dividends.

In short, failure to adjust expectations to the state of the market at those points in time caused considerable pain for many people as well as institutional investors—such as pensions. In order to mitigate the effects of a downturn, it is important both to discount at a realistic rate of return on assets and to adjust that expected rate of return as market conditions require.

In 1919, the price-to-earnings ratio in the S&P 500 stood at less than 6:1 and over the next 10 years produced a real total return of 19 percent per year. By contrast, the PE ratio had skyrocketed to over 40:1 in 1999. From 1999 to 2009 the real total return on the S&P 500 was -4.2 percent per year. In neither 1919 nor 2009 should one have expected a normal rate of return on stocks. **Figure 1** below shows the historical relationship between the PE ratios and stock returns.

FIGURE 1
10-Year Forward Real Annual Return to S&P 500 and PE Ratio
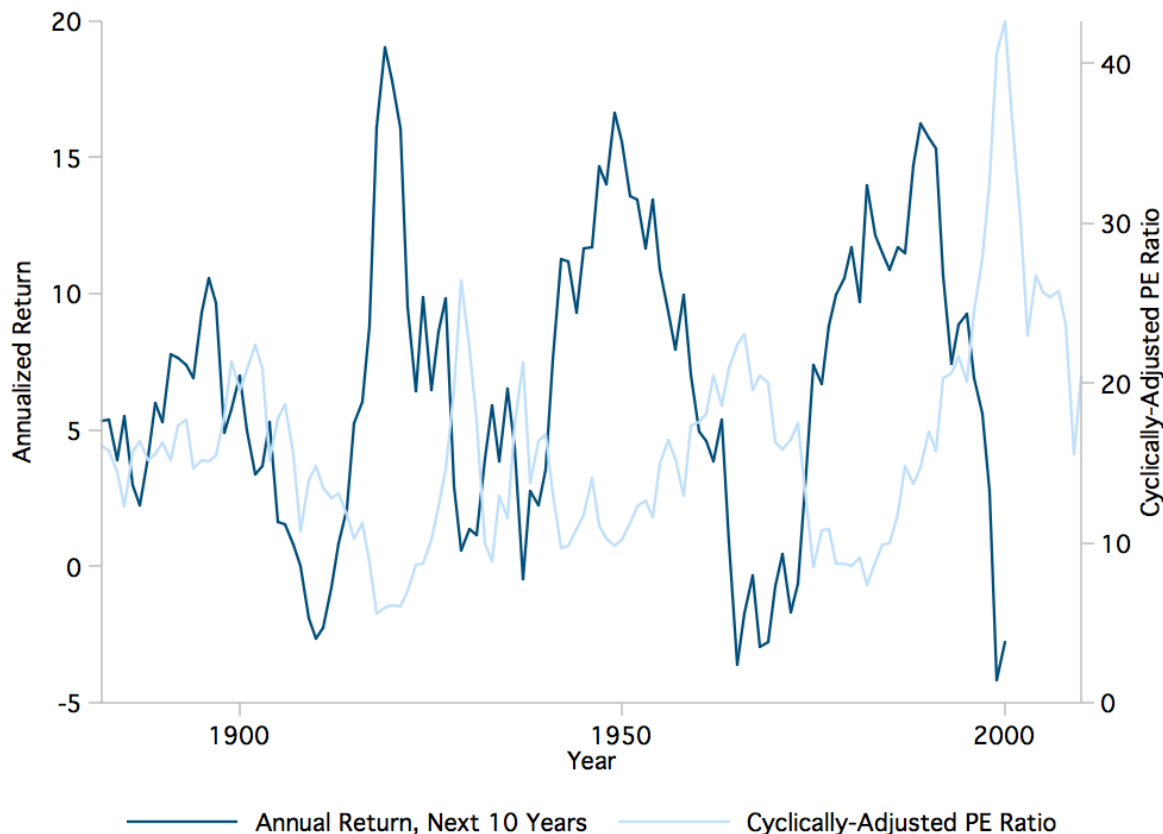
Sources: Shiller (2005), Shiller (2011), and authors' calculations.

Thus, we propose a rule for conditionally adjusting the expected rate of return on stocks so that the PE ratio returns to 15:1 over the course of 10 years based on projected earnings.

Simulation under Different Rules

We now compare pension performance under different discount rates: first by selecting a risk-free rate based on 10-year Treasury bonds plus one percentage point, then by selecting an economically-conditional rate based on a portfolio of 60 percent stock and 40 percent risk-free bonds. In each case the actual portfolio is 60 percent S&P 500 stock and 40 percent bonds, but the conditional discount rate is adjusted each year for the current PE ratio as discussed above.

The first difference between the two pensions is the level of assets required in each case to be considered fully funded. As the S&P 500 can be generally expected to outperform bonds, the conditional rate at such times discounts more heavily future payouts and therefore carries a lower asset burden than a pension using a risk-free rate. **Figure 2** shows that in a typical year some $1.30 in assets are required under the lower risk-free rate for every dollar required under the economically conditional rate.

FIGURE 2
Level of Pension Assets Required to Qualify As Fully Funded under "Economically-Conditional" and "Risk-Free" Discount Rates
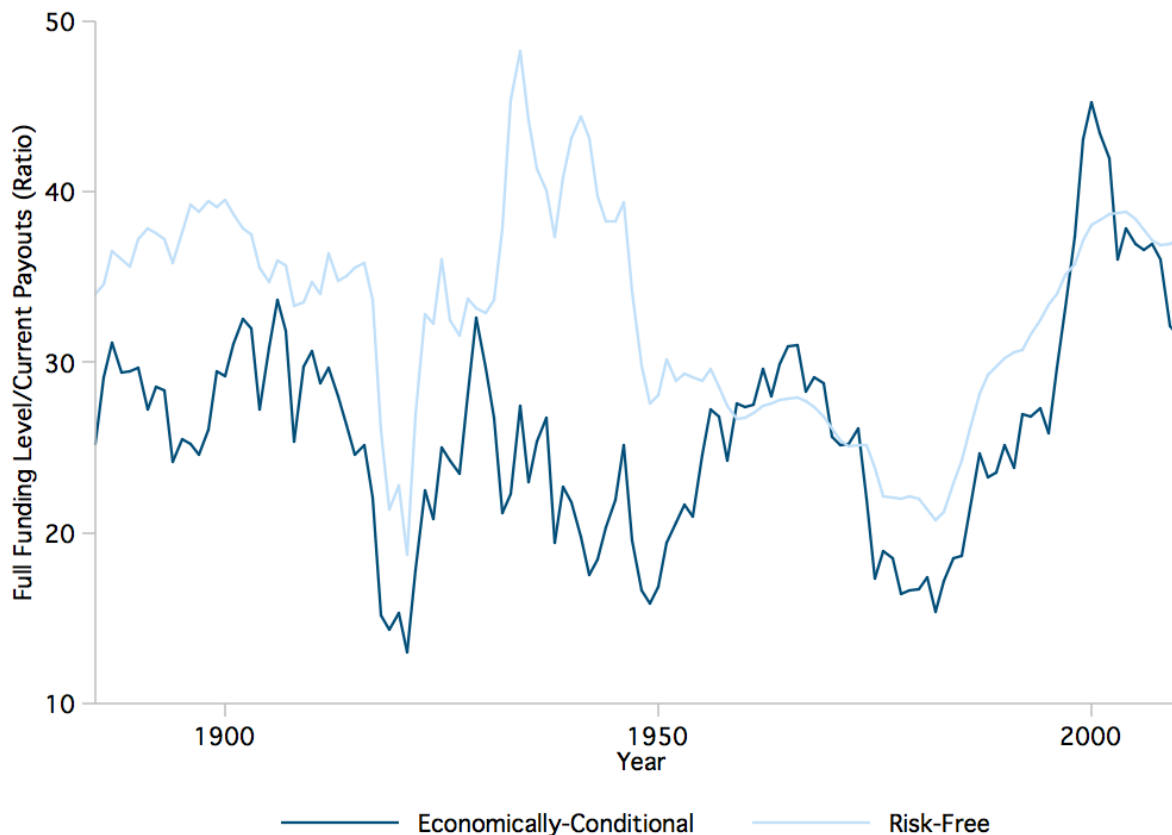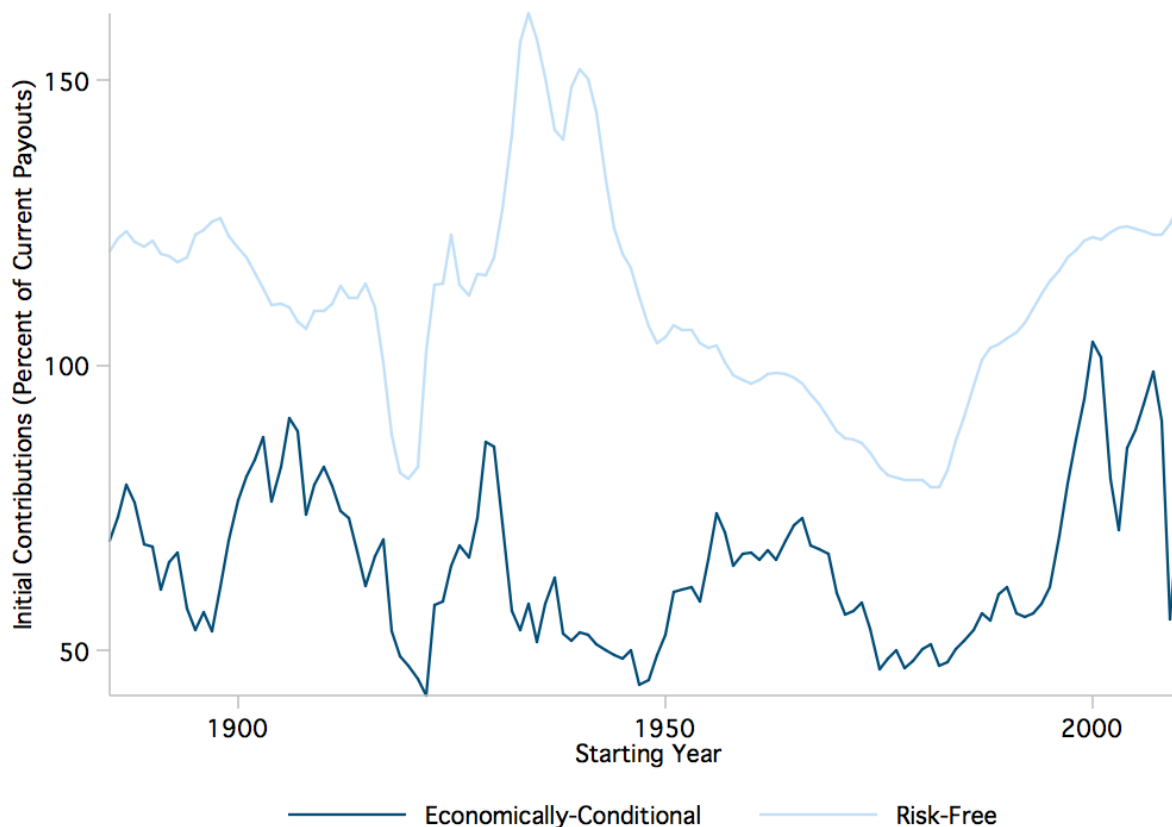

Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

Of particular interest is the late 1990s, when the relationship inverts. As the stock market became overvalued, the expected return on stocks fell well below that of safe bonds. Rather than relying on an already-large stock of assets, the choice of a conditional discount rate required additional asset accumulation to build up a reserve against the expected fall in stock prices. By construction, this build-up would have taken place during the run-up of asset prices. Rather than requiring very large contributions, the bubble itself would have done much the "work" of building up the asset base. Consequently, any taxes required would not have been greatly burdensome.

Similarly, as the bubble burst, the conditional rate fell, permitting the pension to maintain a smaller base of assets. Yet the choice of a risk-free rate would have required the maintenance of a large base of assets even as those pension assets lost considerable value. In order to prevent that fall, larger contributions would be needed.

In **Figure 3**, we see the required contributions under each discount rate, assuming that each pension is fully funded at the start of the year. Typically, the conditional discount rate would require contributions to a fully funded pension in the amount of 50 to 100 percent of annual payouts. By contrast, a risk-free discount rate would require much larger contributions.

FIGURE 3
Pension Contribution Rates Required to Maintain Full Funding Under Conditional and Risk-Free Discount Rates
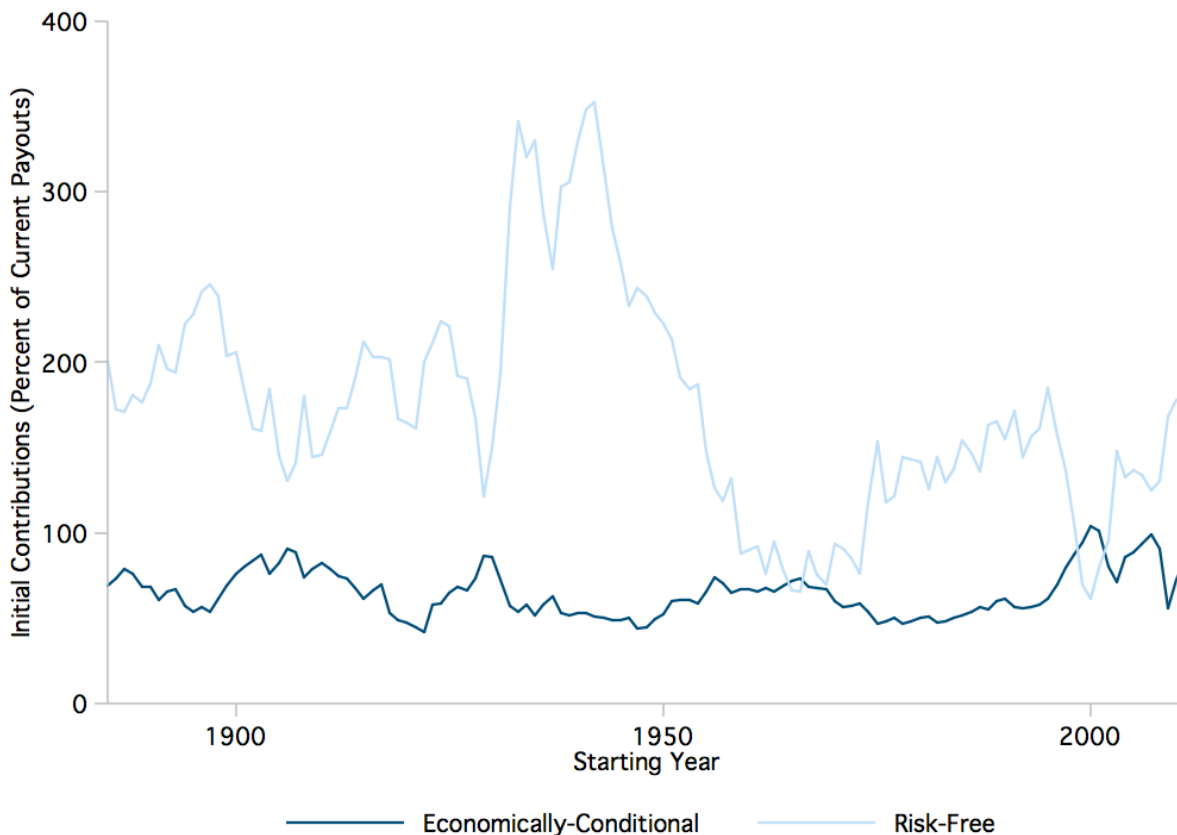

Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

In 2000, the economically-conditional rate of return on stocks was extremely low. The choice of conditional discount rate required a higher contribution rate than that of any other of any year on record. Yet, a pension fully funded under the choice of a risk-free rate would have required contributions even larger than those under the conditional rate.

Of course, pensions are rarely exactly fully funded. During the run-up of an asset bubble, the pension may become overfunded, leading to a fall in contributions. Rather than examining fully funded pensions in various years, it is important to observe the performance of pension rules over time.

First, a proposed *switch* in the discount rate affects the current funding status of the pension. Absent a very large contribution, a decrease in the chosen discount rate pushes a pension farther below full funding, as in the examples of Table 4. **Figure 4** shows the first-year contribution rates under two scenarios. In each, the pension begins fully funded based on a conditional discount rate and must aim to be fully funded in ten years. In one scenario, the pension continues to operate under the conditional discount rate; in the other, the pension immediately switches to a risk-free discount rate.

FIGURE 4
First-Year Pension Contribution Rates Required to Maintain Full Funding under Conditional and Risk-Free Discount Rates

Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

As can be seen in Figure 4, the switch generally results in an immediate underfunding under the new discount rate and so initial contribution rates are much higher. On the other hand, the actual portfolio risk is assumed to be identical, so this often leads to overfunding. **Figure 5** shows simulated pension assets under each discount rate as a share of full funding. In the figure, both are assumed to begin in the year 1885 with identical assets sufficient to fully fund the pension under the economically-conditional discount rate. In that year, the risk-free discount rate implies underfunding, but by 1900 the pension is overfunded.

FIGURE 5
Pension Funding Under Conditional and Risk-Free Discount Rates, 1885 to Present
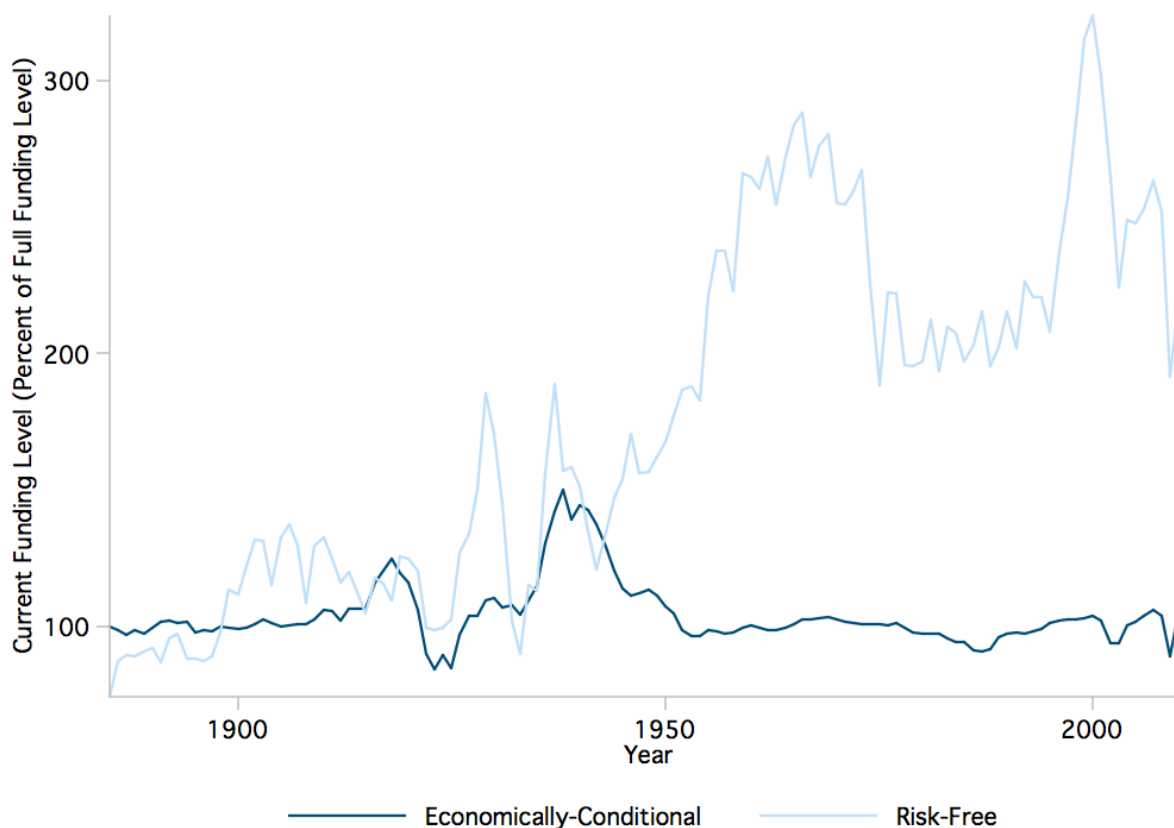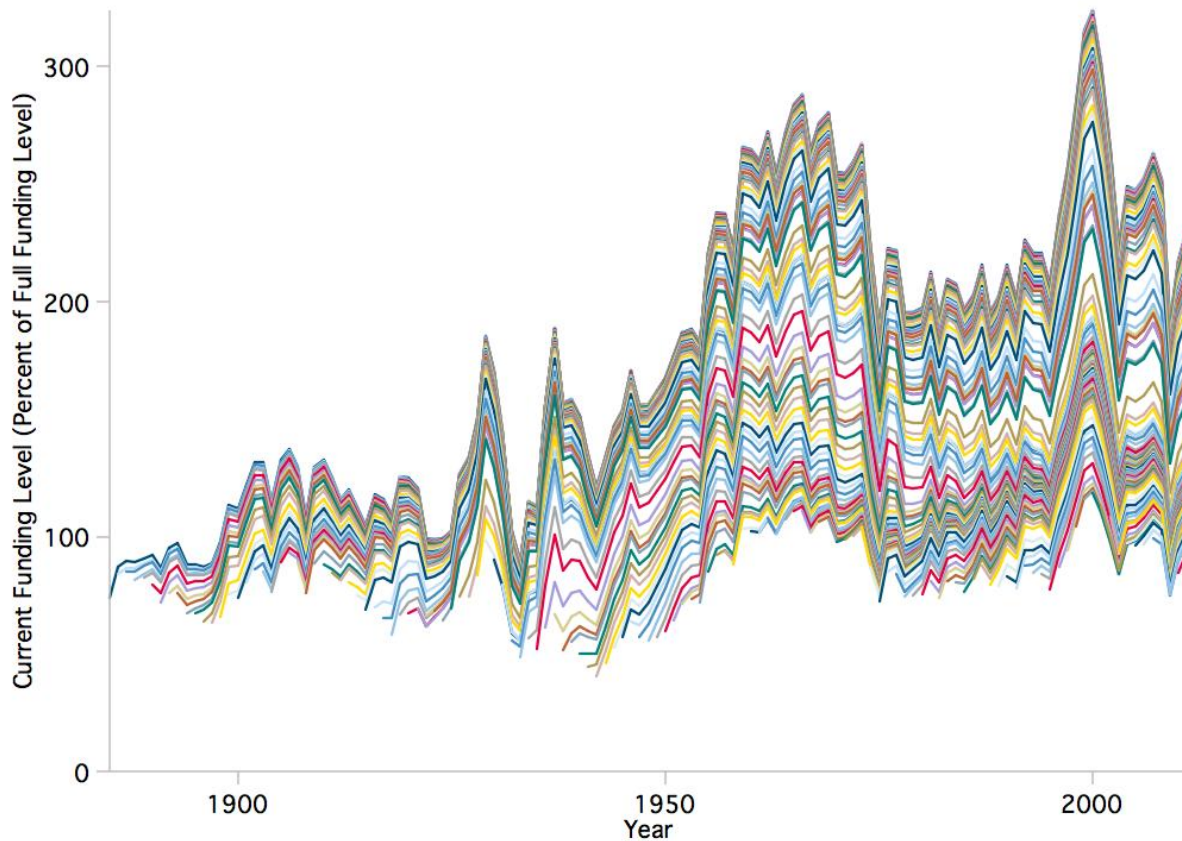

Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts
Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

Over time, the risk-free discount rate leads to a tremendously overfunded pension. By the peak of
the stock bubble, the pension holds more than three times the required assets. At the peak in 2000,
the pension holds assets of more than 120 times the year's payouts and has become entirely pre-
funded—having made no contribution since 1943. While it may be comforting to know that future
pension obligations may be met without making contributions, it is less comforting to know that
baby boomer pensions were paid for primarily by workers who were born during the Civil War and
those who fought in World War II.

The degree of overfunding in and among simulations varies greatly. **Figure 6** shows the simulated
funding levels under a switch to a risk-free discount rate—just as in Figure 5. However, rather than
comparing the funding level to a no-switch baseline, Figure 6 shows the simulation in comparison to
alternative switch dates—1885, 1886, and so on through a switch date of 1995.

FIGURE 6
Simulated Pension Assets—Transition to A Risk-Free Discount Rate by Year of Switch.

Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

There is less variation among the simulations than Figure 6 seems to indicate. In fact, whether or not a pension becomes overfunded depends greatly on the year in which the simulation starts. This is seen in **Figure 7** below. The left of Figure 7 is identical to Figure 6, but shows only the simulations that start in 1885-1918. A switch to a risk-free discount rate in any of these years leads to overfunding. The right of Figure 7 is similar, but shows only the simulations that start in 1936-95. These simulations show pensions that are much less overfunded.
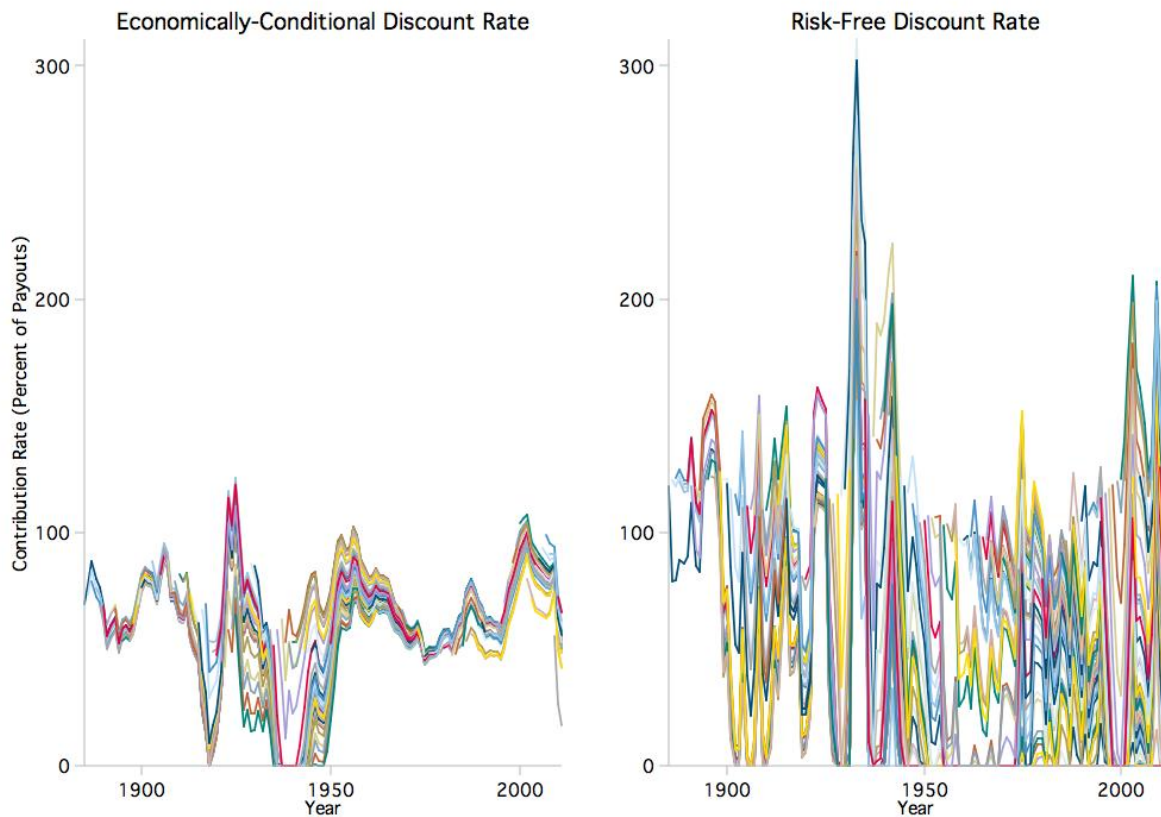
FIGURE 7
Simulated Pension Assets—Starts in 1885-1918 and 1936-1995
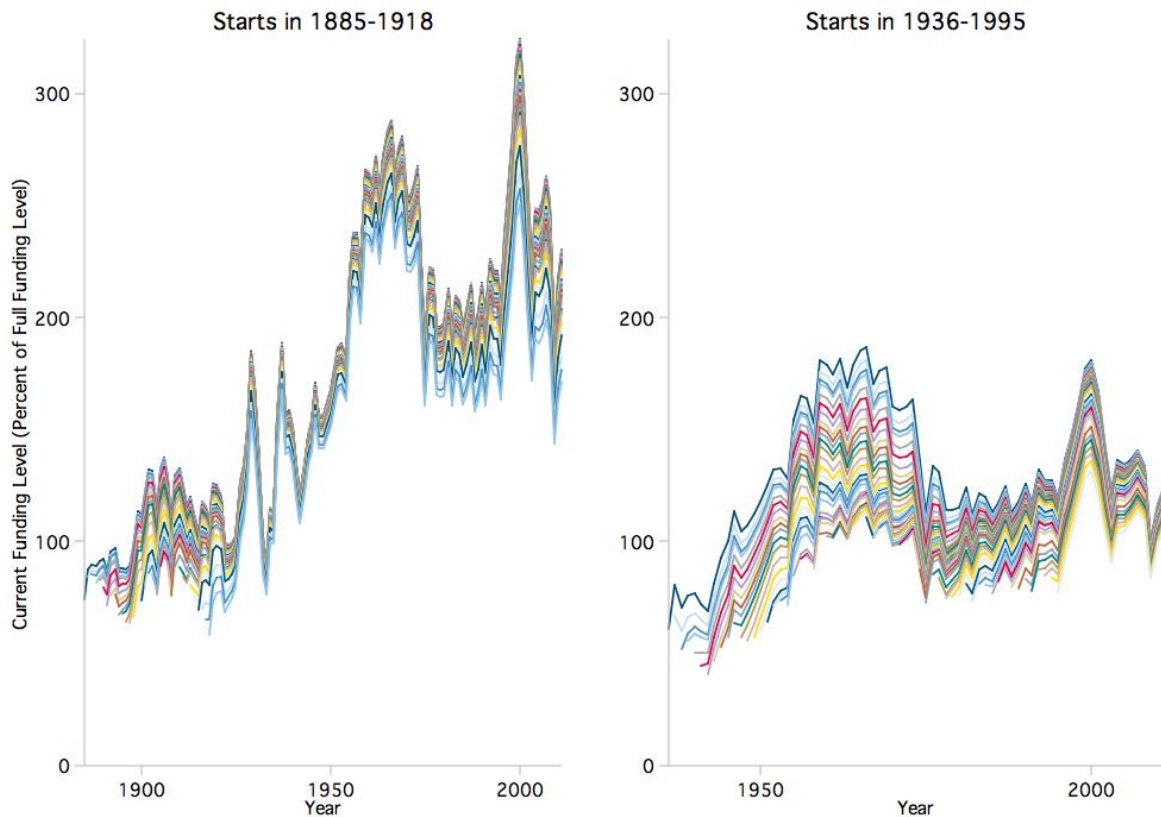
Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

Even pensions that are initially fully funded under the choice of risk-free discount rate may be required to make large contributions over time. On the left of **Figure 8** are the simulated contribution rates over time for pensions operating under the choice of a conditional discount rate. Each line corresponds to a single simulation in which the pension starts fully funded in a given year. In the right are the simulated contribution rates over time for pensions operating under the choice of a risk-free discount rate. Unlike the simulations of Figure 7, these pensions begin fully funded under the risk-free rate, so there is no need for any initial building of assets.
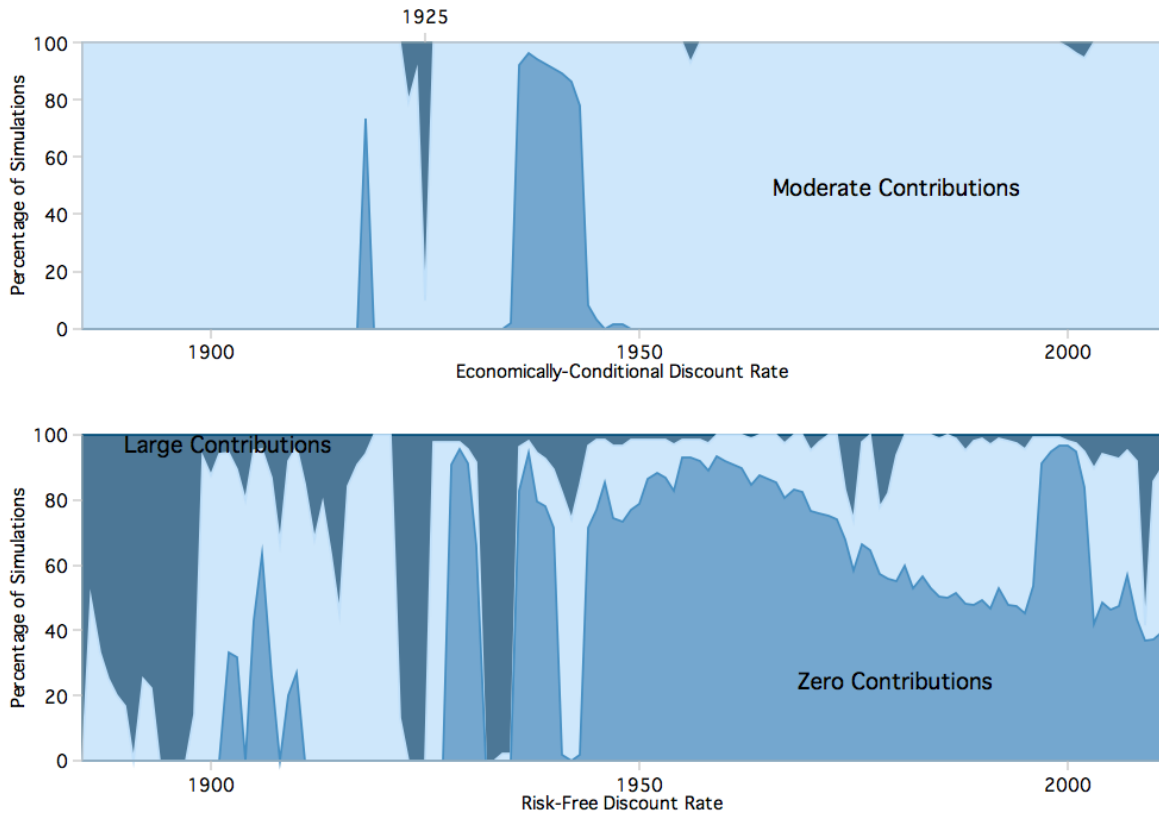
FIGURE 8
Simulated Pension Contribution Rates—Fully Funded At Start of Simulation

Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

Under the economically-conditional discount rate, pensions rarely must make contributions in excess of payouts. That is, in most years benefits are partially funded out of assets and interest. On the other hand, it is far more common for a pension funded under a risk-free discount rate to pay current benefits exclusively out of contributions. **Figure 9** shows the percentage of simulations in which required contributions are zero (green), less than or equal to payouts (red), and greater than payouts (blue).

FIGURE 9
Percentage of Simulations with Zero, Moderate and Large Contributions
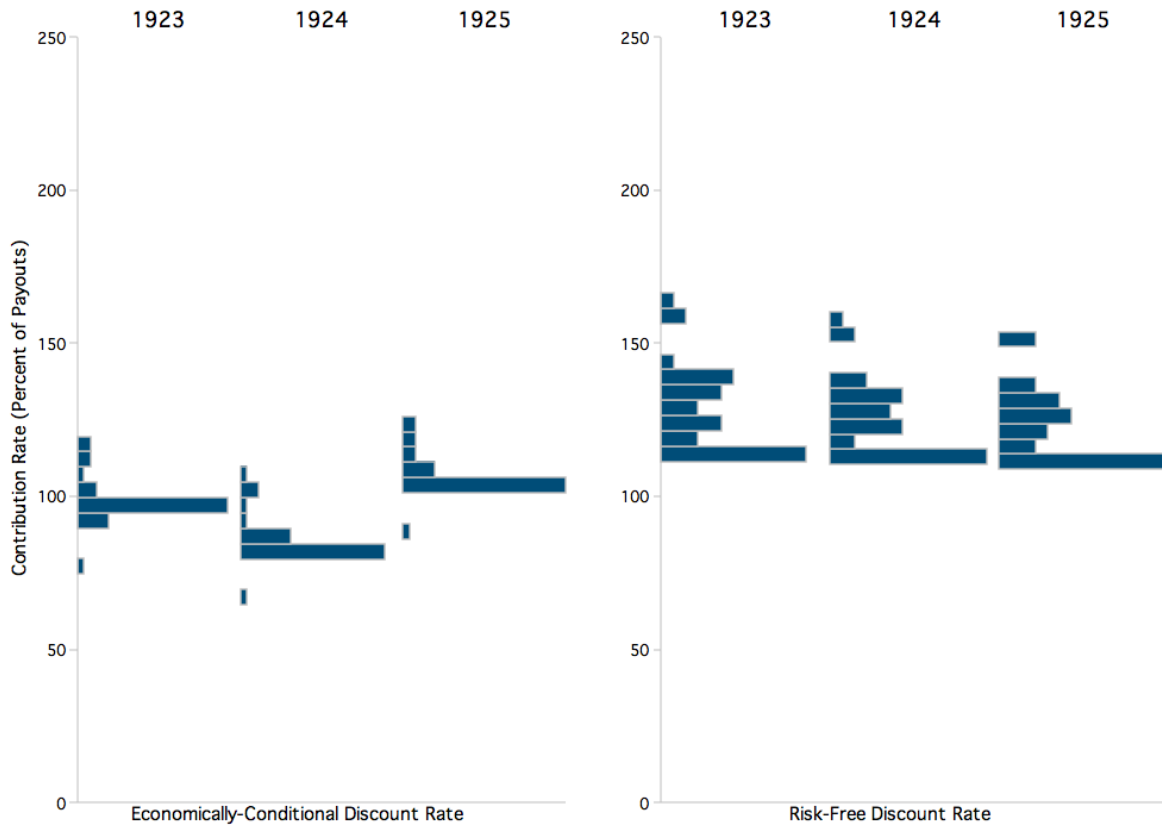

Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

We can see in Figures 8 and 9 that the worst outcomes under the conditional discount rate (that is, with the greatest need for contributions) come in the early 1920s. Even so, the required contributions under the risk-free discount rate are even larger in these years. **Figure 10** below shows the range of simulated contribution rates in the years 1923-25. As above, these simulations all start with fully funded pensions, and therefore do not reflect the need to build up assets in moving to a risk-free discount rate.

FIGURE 10
Distribution of Simulated Contribution Rates By Year—1923-25 (Simulations Starting Fully Funded in 1885-1922)

Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

Similarly, the contribution rates in the lead-up to and through the early part of the Great Depression are striking, as shown in **Figure 11**.

FIGURE 11
Distribution of Simulated Contribution Rates By Year—1927-35 (Simulations Starting Fully Funded in 1885-1926)
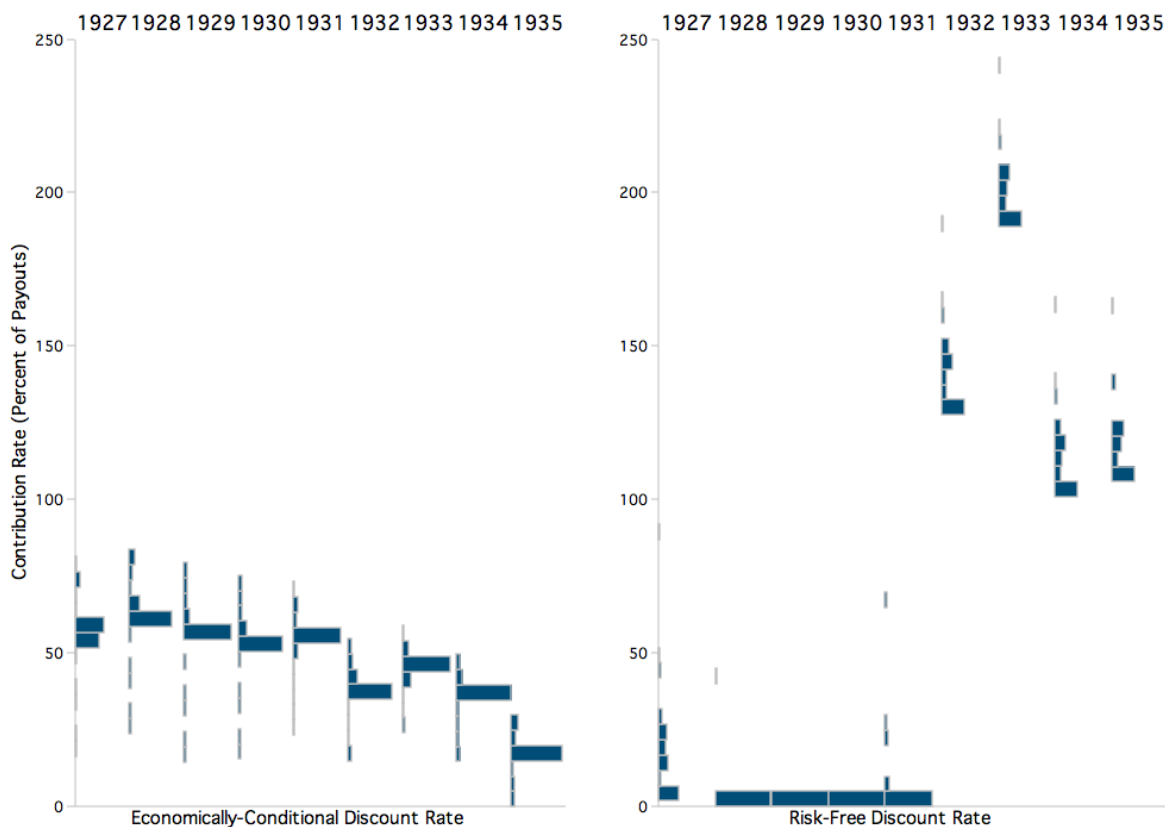
Sources: Johnston and Williamson (2011); Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10; Shiller (2005), Shiller (2011), and authors' calculations.

Although economically-conditional pension contributions were modest prior to the Great Depression, the PE ratio for the S&P 500 fell below 10:1 in 1932-33—indicating an unusually large expected return.   Thus, contribution rates actually fell after the crash under the choice of economically-conditional discount rate. By contrast, the use of a risk-free discount rate meant very low contribution rates as the stock market inflated—recognizing the existence of a very large asset cushion. However, the implicit failure in the choice of risk-free discount rate to recognize that the market had subsequently overcorrected and would yield larger returns in turn exaggerated a need for very large contributions at the worst possible time.

In effect, using the risk-free rate of return assumption would have required governments to impose large tax increases to fully fund their pensions in the middle of the Great Depression – even though such contributions were in fact unnecessary to maintain full funding, given the resulting returns in the stock market.

Conclusion

The participants in the debate over pension accounting have a variety of agendas. If the purpose is to make the situation of these pension funds appear as dire as possible, then using a risk-free rate of return to assess their liabilities can be useful. However if the goal is to actually manage a pension fund holding equities in a way that minimizes the need to increase contributions above the normal level, and therefore implicitly raise taxes, then it is desirable to use a funding rule that is based on an economically conditional rate of return of the assets held by the fund.

This paper uses data on stock returns dating back to the late 19th century to show that a pension fund that adjusted its expected return assumptions based on the ratio of stock prices to trend earnings would have a much smoother contribution path than a fund that always maintained full funding using the risk-free rate of return as the discount rate. The smoother funding course results not only from avoiding high taxes during the initial build-up period, but also by avoiding the sharp increases in funding that would be required after stock market crashes, such as those of 1929-30 and 2000-2002.

The choice of a risk-free discount rate reduces the risk that the long-run future value of assets is overstated. However, in pension management that choice is not effective in avoiding the risk of improper funding. If the goal of pension fund managers is to maintain a smooth flow of funding and avoid temporary tax increases needed to meet funding targets, then the conditional funding rule described in this paper is unambiguously superior to a funding scheme that maintains full funding using the risk-free rate of return as the discount rate.

Appendix: Forecast Methodology

The historical index of risk-free returns is constructed from the Shiller 10-year bond data (Shiller 2011), assuming a one-percentage-point premium reinvested annually.

The GDP deflator is assumed to increase at the rate of the five years prior to and including the base year of the forecast. All base-year prices (including January S&P) are known accurately. All "real" values are discounted by the GDP deflator. (For 1929-2010, GDP and wage data are taken from the National Income and Product Accounts, Tables 1.1.5, 1.1.6, and 1.10. For years prior to 1929, data was taken from Johnston and Williamson (2011).

In this paper, several long-term trends are constructed and used for forecasting purposes. In most cases the data is log-transformed, a trend is estimated to be quadratic in time, and over 10 years from the most recent available data at the start of forecast. A return to that trend is assumed. In general, forecasts made in January of a base year include historical data through the year prior.

These trends include:

- Population growth starting in 2011. Pension managers are explicitly assumed to otherwise accurately forecast population, rather than project a return to trend.
- Real GDP per-capita.
- Wage share of GDP. The (log) wage share prior to 1929 is assumed equal to the average in the years 1929-71. From 1971 on, the trend is quadratic, but assumed to remain flat over time rather than swing upward.
- A "risk-free" bond index. The trend in the log index is assumed linear.
- Real earnings. (The nominal earnings and dividends for each year are Shiller's figures for December of the year.)

Pension payouts in each year are assumed to equal 95 percent of the previous year's payouts (adjusted for price level of GDP), plus 0.1 percent of nominal wages (actual or projected) in each of the five prior years.

Price forecasts for the S&P 500 are constructed based on a return to a cyclically adjusted PE ratio of 15 over 10 years. The PE ratio is constructed identically to Shiller's formulation (except for the use of GDP deflator in lieu of CPI). Specifically, the historical PE ratio is computed as the real S&P 500 index divided by the average real earnings over the prior 10 years. Over the next 10 years the PE ratio is assumed to move linearly to a value of 15 in the 10th year after the base year of the forecast. The forecast PE ratio is multiplied by the projected GDP deflator and projected 10-year average real earnings in order to arrive at a price projection.

Dividends are forecast in multiple steps. First, the historical dividend-to-earnings (DE) ratio is computed by dividing the average real dividends over the prior 10 years by the average real earnings over the prior 10 years. Initially, the DE ratio is assumed to be unchanged in the forecasts, and therefore the unadjusted real annual dividends are those that maintain the DE ratio given the real earnings. The (log) unadjusted dividends are replaced by their trend over the forecast period.

Pension Management

Pensions are assumed to rebalance each January (base year/"year zero") to hold 60 percent S&P 500 stock and 40 percent risk-free bonds. All dividends are reinvested, payouts and (if any) contributions made just prior to rebalancing. The above forecast produces a discount rate based on the economically conditional rate of return on this pension portfolio as well as a risk-free rate based on 100 percent bonds. Regardless of the discount rate applied, the actual pension portfolio is assumed to be "economically conditional" in the sense that the year-to-year return on the actual assets is uncertain.

Our rule for a fully funded pension is that it holds assets equal to 100 percent of the present value of payouts over the next 30 years (years 0-29). Thus, the assets required to meet the funding rule depends on the choice of discount rate. Any pension shortfall must be restored over the next 10 years as follows:

Current assets (less) discounted payouts in years 0-9 are subtracted from discounted payouts in years 10-39 to find the present value of contributions which must be made in order to forecast a fully-funded pension in year 9. (Equivalently, the discounted contributions must equal the difference between discounted payouts in years 0-39 minus current assets.) The contribution rate is defined as this present value of required contributions divided by the present value of payouts over years 0-9. If the contribution rate is positive, then current-year contributions are made in the amount of current-year payouts times the contribution rate.

In the first January of a multi-year simulation of pension performance, the "economically conditional" pension is assumed to hold assets sufficient to make it fully funded with respect to that conditional discount rate. Typically, the "risk-free" pension is assumed to start with the same assets, but in some simulations may instead begin fully funded with respect to the choice of risk-free discount rate.

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