

Pension Liabilities: Fear Tactics and Serious Policy

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Abstract

There is major national debate over the funding status of state and local pension funds. Many economists have argued that pension funds are being overly optimistic in assuming that pensions will be able to get 8 percent nominal returns on their invested funds. This calculation is based on the historic average of the mix of assets that are held by these funds. They have argued that funds should instead that their assets will get the risk-free rate of return on US Treasury bonds and build up their funds accordingly. This paper applies a funding rule projects returns based on current price to earnings ratios in the stock market. It runs a number of simulations based on the pattern of stock returns since the beginning of the last century. It shows that in all cases this funding rule would imply a more even flow of payments to the pension fund than a funding rule that assume a risk-free rate of return. The implication of this analysis is that if state and local governments want to maintain a relatively even flow to their pensions and not burden taxpayers at certain points in time with excess burdens, pensions should adopt a funding rule like the one described in this paper.

Introduction

The last two decades have generated substantial demand for accounting techniques that paint a dire picture of government finances. In the early 90s we had 'generational accounting' that showed a lifetime tax burden for generations yet to be born of 80 or 90 percent (Auerbach et al 1991; Kotlikoff, 1993, and Auerbach et al 1995). After this became discredited (Baker 1995; Congressional Budget Office 1995) it became popular to express liabilities of programs like Social Security and Medicare over an infinite horizon (eg. Gokhale and Smetters 2003). These projections could show deficits in hundreds of trillions of dollars. A more modest approach is to calculate the gap between the benefits promised current beneficiaries and the current and past taxes paid by these beneficiaries (eg. Government Accountability Office 2008). This produces a deficit in the high tens of trillions of dollars. This methodology conceals both the fact the numbers actually don't seem that large expressed relative to future GDP and that they are driven almost entirely by projections of explosive health care cost growth in the private sector.

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 state and local government pensions must be understood in this context (eg. Novy-Marx and Rauh 2009). (It is important to note that these are state and local government pensions. These governments are

subject to a hard budget constraint. Unlike the federal government, they do not have the opportunity to simply issue money to finance pensions.) 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 interest rate 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. (The focus of this discussion is state and local pensions. Under the law, these pensions must be financed by the revenue raised by these government entities.)

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

The focus on 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 the expected return on their holdings. As will be shown, the expected return used in making this assessment will vary depending on the current ratio of stock prices to trend corporate earnings¹. 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 periods where price-to-earnings ratios in the stock market get 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 that is hoped to be avoided 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 will

¹ 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 use a lower rate of discount rate than the 8.0 percent that they were then assuming.

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 the bad event that we are seeking to avoid in financing pensions is an excessive tax burden (implied by greater than normal funding levels) at a particular point in time, then a surplus or shortfall are both evidence of bad management.

The rest of this paper describes more carefully this funding rule that discounts future obligations based on our calculations for the expected earnings of 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 assumed a risk free rate of return on assets and funded accordingly.

Alternative pension funding rules: Risk-free rate of return versus expected rate of return

The simulations in this paper define that a pension as being ‘fully funded’ if its current assets suffice to cover the next 30 years of projected payouts based on a given discount rate. In keeping with definition we apply a rule that no matter the current funding level, contributions to the pension must be sufficiently large so that in ten 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.)

In order to make that work, current assets plus discounted contributions over the next ten years must equal discounted payouts over the next 40 years. For a pension that will pay benefits totaling \$1 million this year and 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 to be considered fully funded – more if a lower discount rate is used, and less if a higher discount rate is used. In ten years, however, the pension will need to have \$48.9 million in assets. At 5 percent interest, we need \$30 million today to reach that goal. Consequently, we need to pay the all benefits over the next ten years without touching the initial \$30 million. That is, we need to contribute to the pension at a rate of 100 percent of current payouts.

Table 1: Computing Contributions To A Fully Funded Pension

Discount Rate	Initial Assets	Discounted Payouts		Contributions Years 1-10	Contribution Rate
		Years 1-10	Years 11-40		
(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

Note that a contribution rate of 100 percent means that \$1 million in payouts must be combined with \$1 million in contributions to the pension fund.

Now suppose that we assume an 8 percent discount rate. Because we are imputing a higher rate of interest on assets, then to be fully funded today, we need only \$20.5 million. Of this, we need only set aside \$15.5 million today to have the required \$33.5 million needed ten years from now. This leaves \$5 million, which may be used to pay benefits over those ten years. At our 10 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 we will still be fully funded in ten 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.

Although the pension manager chooses the discount rate, the actual return on pension assets is determined by the market return on the assets held. In Table 2, we see the results after one year assuming the mix of assets in each case is exactly the same and produces a 5 percent return.

Table 2: First Year Performance of a Fully Funded Pension – 5% Interest

Discount Rate	Initial Assets	Payouts	Contributions	Interest Income	Assets at End of Year	Full Funding in Start of Next Year
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, a discount rate lower than the actual return on assets results in an overfunding of the pension while a higher discount rate leads to underfunding. These funding issues may be chronic, with contribution rates falling over time. With a lower discount rate 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 a policy choice that lowers the discount rate may help prevent underfunding, a fully funded pension with a low discount rate will suffer correspondingly larger losses in a bad market and necessitating even greater contributions to rebuild those assets. In Table 3 we see the contribution rates needed in response to an initial underfunding of 20 percent based on various discount rates.

Table 3: Computing Contributions To An Underfunded Pension

Discount Rate	Initial Assets	Discounted Payouts		Contributions Years 1-10	Contribution Rate
		Years 1-10	Years 11-40		
(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

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.

Finally, even if a bad market never comes, shifting policy from a higher to lower discount rate requires the immediate building of assets. Suppose we wish to protect ourselves against a situation in which the pension is only 80 percent funded at a 5 percent discount rate – i.e., we have \$24 million on hand. In order to avoid a future \$6 million shortfall, we lower the discount rate to 3 percent *today*, resulting 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: Computing Contributions To A Pension With \$30 Million In Assets

Discount Rate	Initial Assets	Discounted Payouts		Contributions Years 1-10	Contribution Rate
		Years 1-10	Years 11-40		
(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

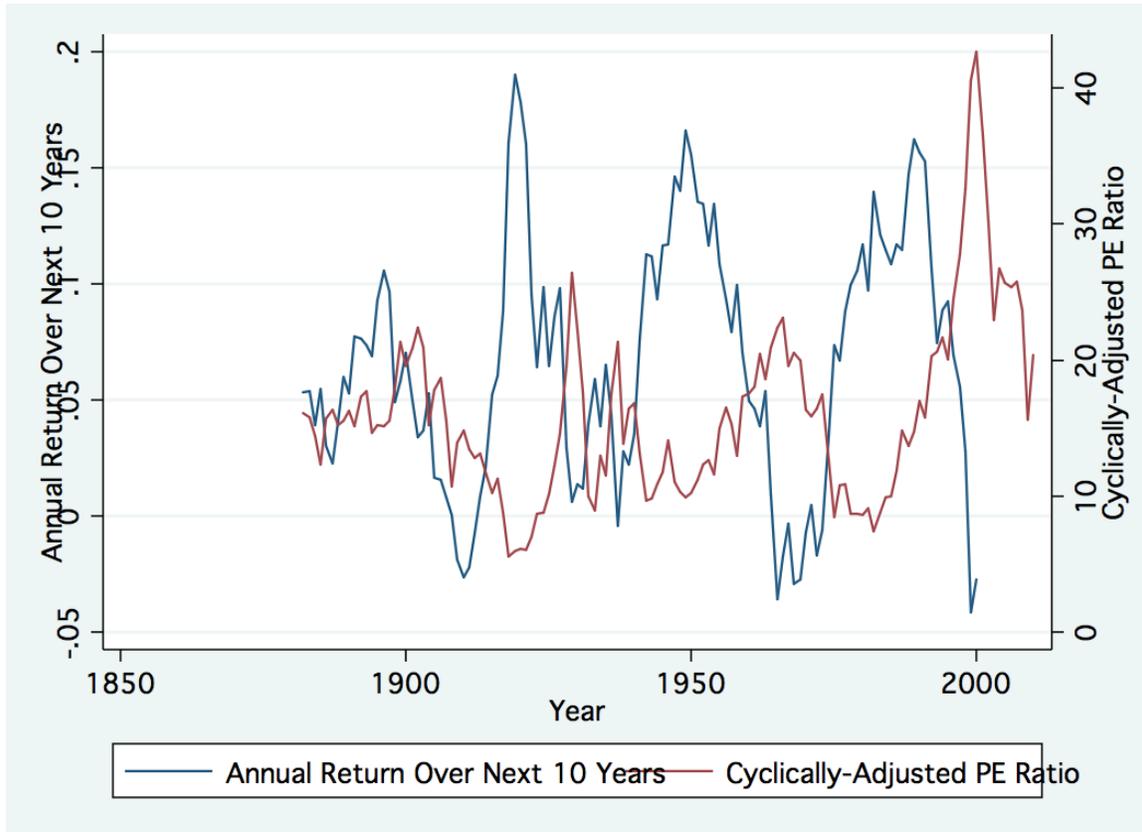
Lowering the discount rate is a strange policy choice that avoids possible large future contributions by insisting on large contributions today. But the greatest risk of adverse market outcomes does not come from a collapse in the price of a fairly valued asset temporarily becoming undervalued. Rather,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

In the housing bubble of the 2000s, there was a prevailing insistence that housing prices could not fall. Lenders egged on 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 returns 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 to the current state of the market 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 the expected rate of return on assets and to adjust the 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 ten 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 typical return on stocks. Figure 1 below shows the historical relationship between the PE ratio and stock returns.

Figure 1: Ten-Year Forward Real Annual Return to S&P 500 and PE Ratio



Sources: Robert Shiller² and authors' calculations

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

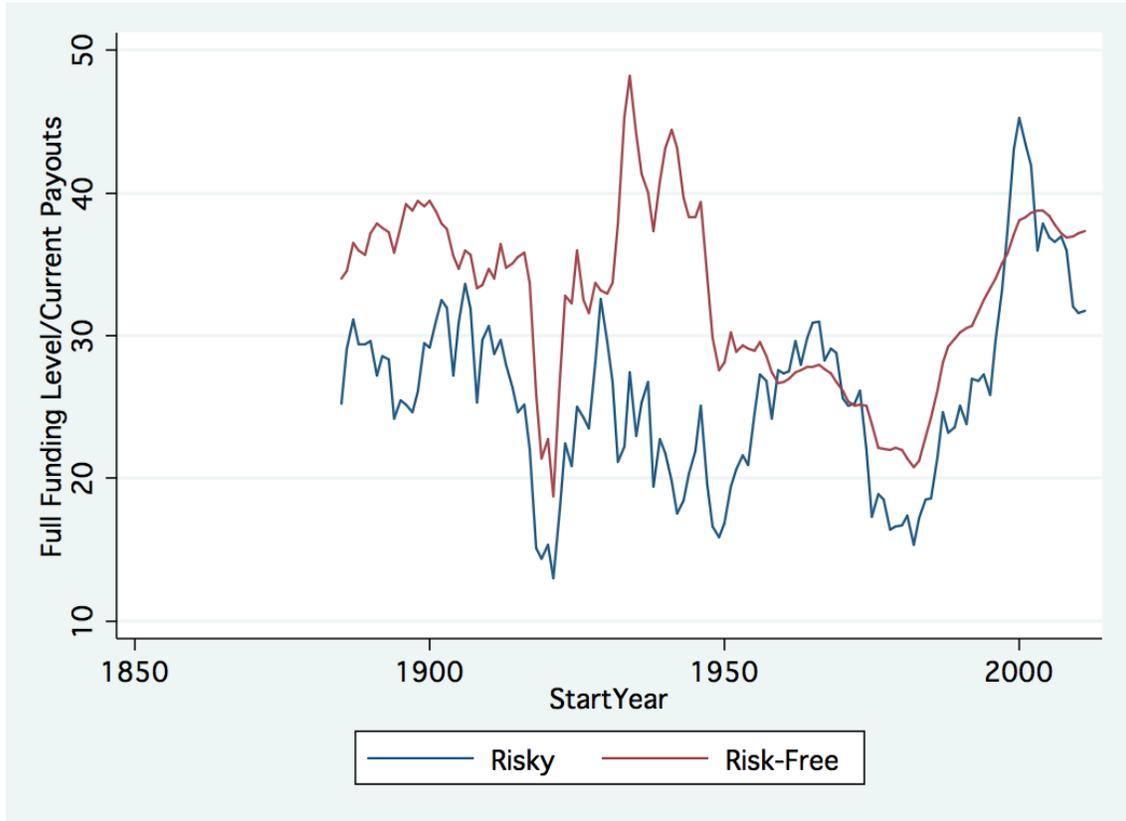
Simulation Under Different Rules

We now compare pension performance under different assumptions for the discount rate: first by assuming a 'risk-free' rate based on ten-year Treasury bonds plus one percentage point, then by assuming a 'risky' rate based on a portfolio of 60 percent S&P 500 and 40 percent 'risk-free'. In each case the actual portfolio is 60 percent stock and 40 percent bonds, but the 'risky' discount rate is adjusted 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 'risky' rate 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 the typical year some \$1.30 in assets are required under the lower rate for every dollar required when setting the discount rate equal to the expected rate of return on the portfolio assets.

² [http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>]

Figure 2: Fully Funded Pension Assets



Sources: Louis Johnston and Samuel H Williamson, 'What Was the US GDP Then?' MeasuringWorth, 2011³, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller⁴, and authors' calculations

Note in particular the period of 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 risky funding rule required additional contributions to build up a reserve against the expected fall in stock prices. By construction, this build-up takes place during the run-up of asset prices and so the contribution requirements are not great.

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 risky 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 fully funded pension contributions.

³ Available from [<http://www.measuringworth.com/usgdp>].

⁴ Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

Figure 3: Contribution Rates Toward Fully Funded Pensions



Sources: Louis Johnston and Samuel H Williamson, 'What Was the US GDP Then?' MeasuringWorth, 2011⁵, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller⁶, and authors' calculations

Even in 2000, when a fully funded risky-rate pension would have been at the most risk, the contribution rate needed to sustain full funding was less than was typical for a pension working from a risk-free rate.

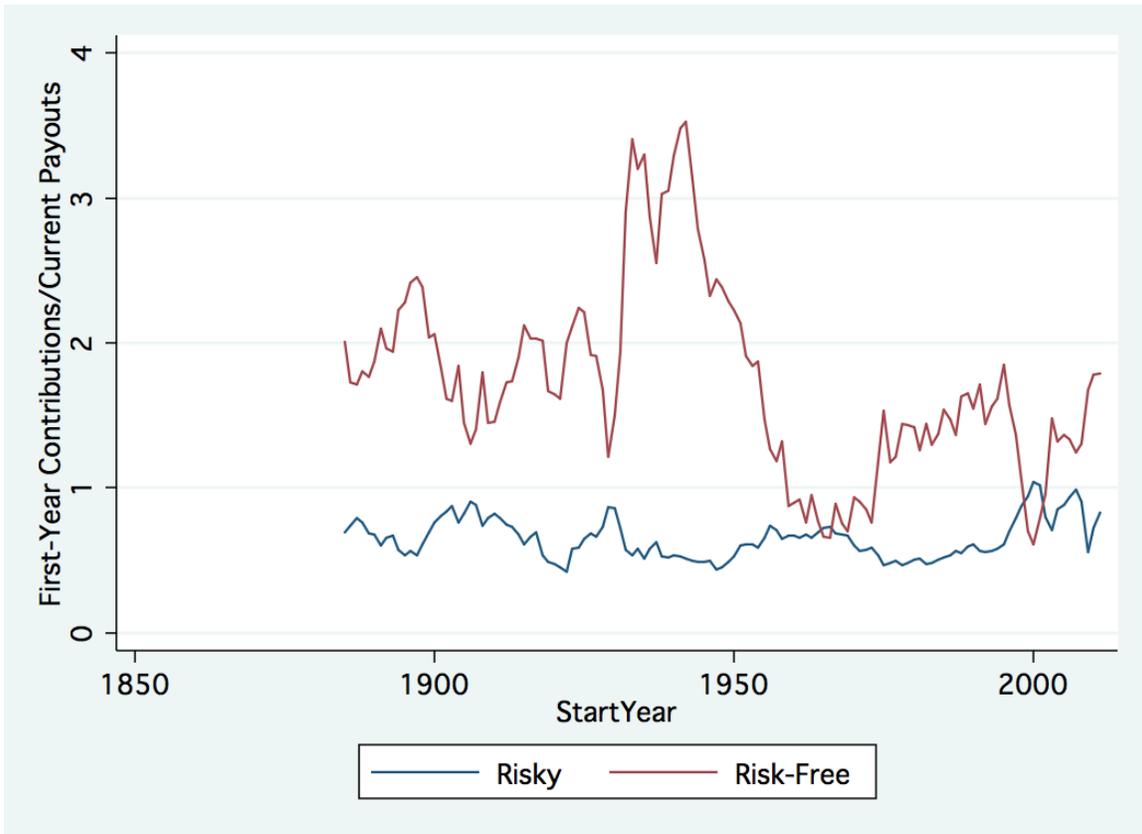
Of course, pensions are not always fully funded. During the run-up of an asset bubble, the pension may become overfunded leading to a fall in contributions. Rather than examining fully funded pensions in various years, it is important to observe the performance of pension rules over time.

The first thing to note is that a proposed switch in the discount rate affects the current funding status of the pension. Absent a very large contribution, a cut in the 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 each discount rate, assuming that the risky pension is fully funded and the risk-free pension must adjust over ten years to full funding.

⁵ Available from <http://www.measuringworth.com/usgdp>

⁶ Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

Figure 4: First Year Contribution Assuming Equal Starting Assets



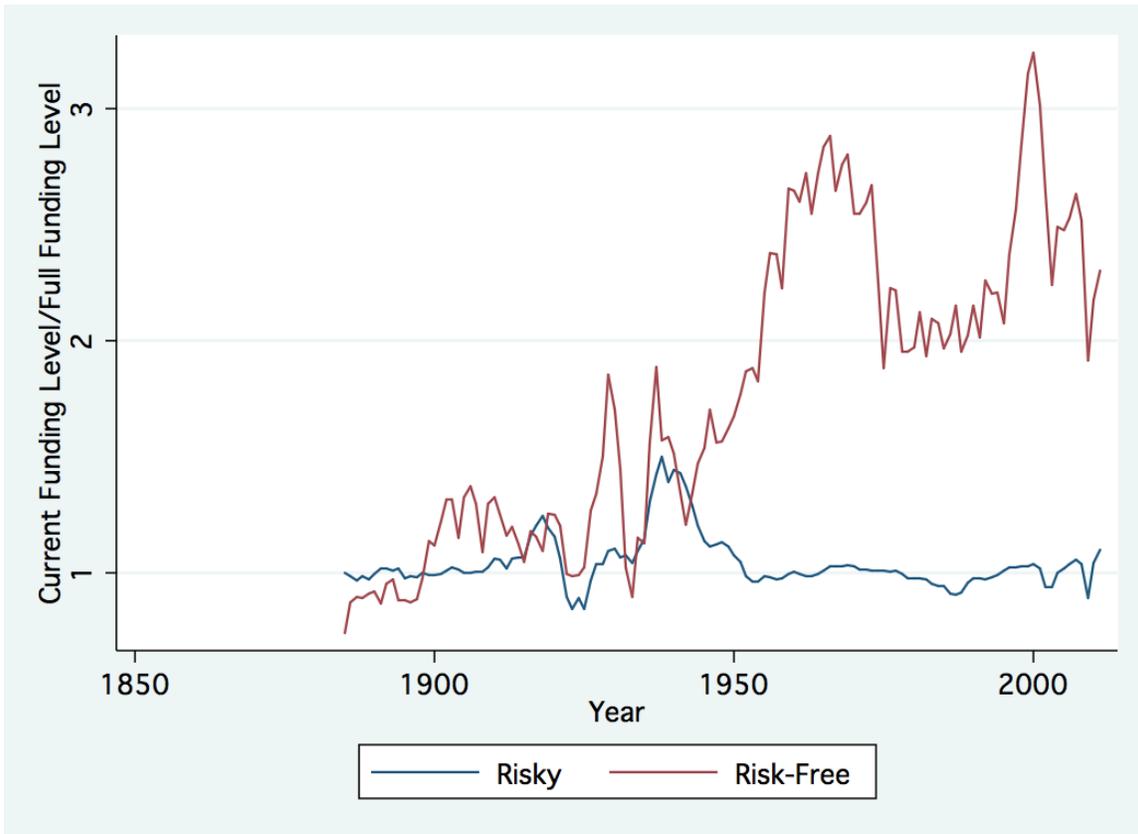
Sources: Louis Johnston and Samuel H Williamson, 'What Was the US GDP Then?' MeasuringWorth, 2011⁷, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller⁸, and authors' calculations

As can be seen in Figure 4, the initial contribution rates are much higher under the risk-free discount rate. 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 under the risky discount rate. In that year, the 'risk-free' discount rate implies underfunding, but by 1900 the pension is overfunded.

⁷ Available from <http://www.measuringworth.com/usgdp>

⁸ Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

Figure 5: Simulation of Pension Funding – 1885 Start Year



Sources: Louis Johnston and Samuel H Williamson, 'What Was the US GDP Then?' MeasuringWorth, 2011⁹, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller¹⁰, and authors' calculations

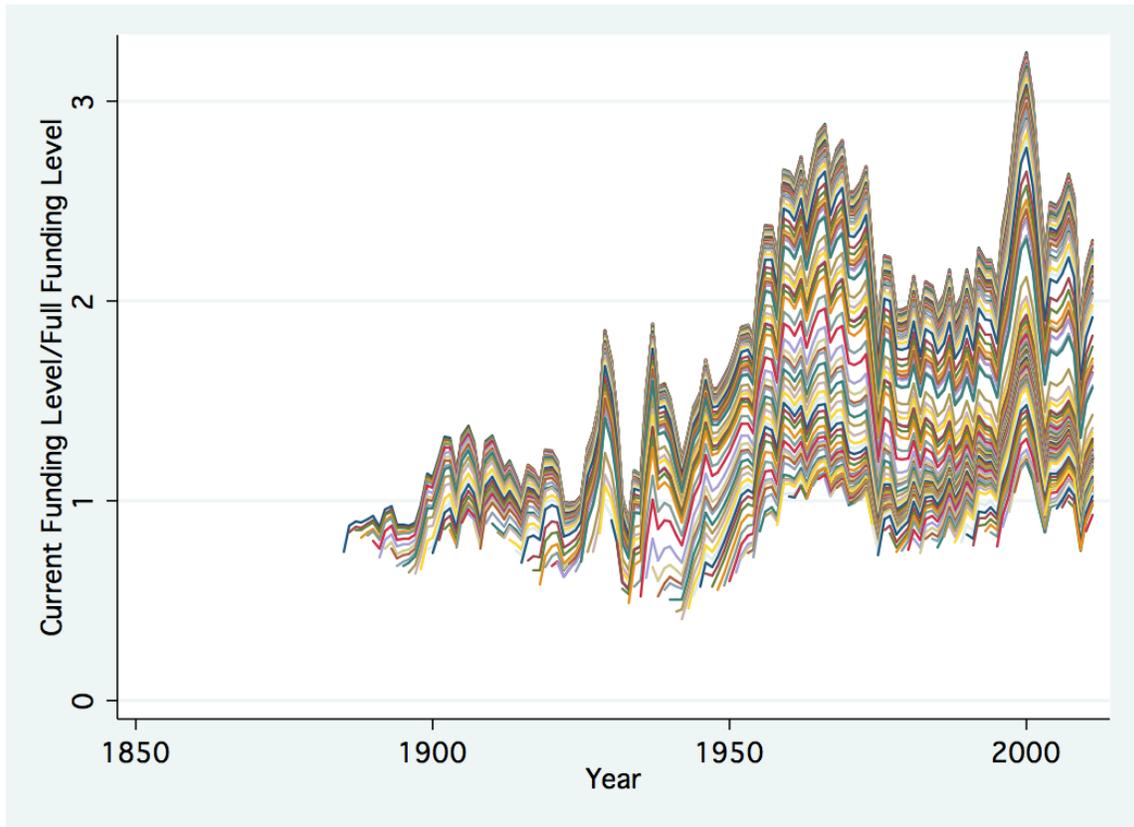
Over time, the risk-free discount rate leads to a tremendously overfunded pension. By the peak of the stock bubble, the pension holds more than three times the required assets. At the peak in 2000, the pension holds assets of more than 120 times the year's payouts and has become entirely pre-funded – having made no contribution since 1943. While it may be comforting to know that future pension obligations may 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 then by 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 the risk-free discount rate starting with assets sufficient to fully fund under the risky rate.

⁹ Available from <http://www.measuringworth.com/usgdp>

¹⁰ Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

Figure 6: Simulated Pension Assets – Switch to Risk-Free Discount Rate



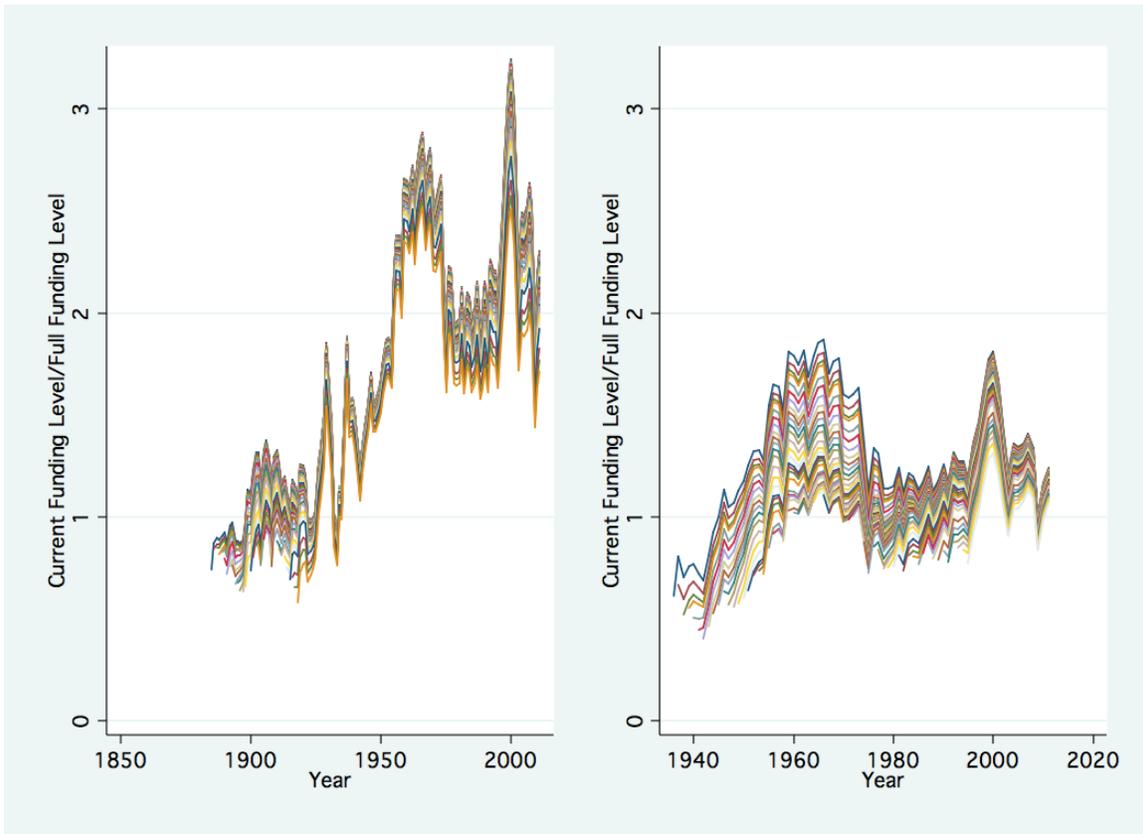
Sources: Louis Johnston and Samuel H Williamson, 'What Was the US GDP Then?' MeasuringWorth, 2011¹¹, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller¹², and authors' calculations

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. Simulations that start in 1885-1918 will greatly overfund, and simulations that start in 1936-1995 less so. This is seen in Figure 7 below.

¹¹ Available from <http://www.measuringworth.com/usgdp>

¹² Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

Figure 7: Simulated Pension Assets – Starts in 1885-1918 and 1936-1995



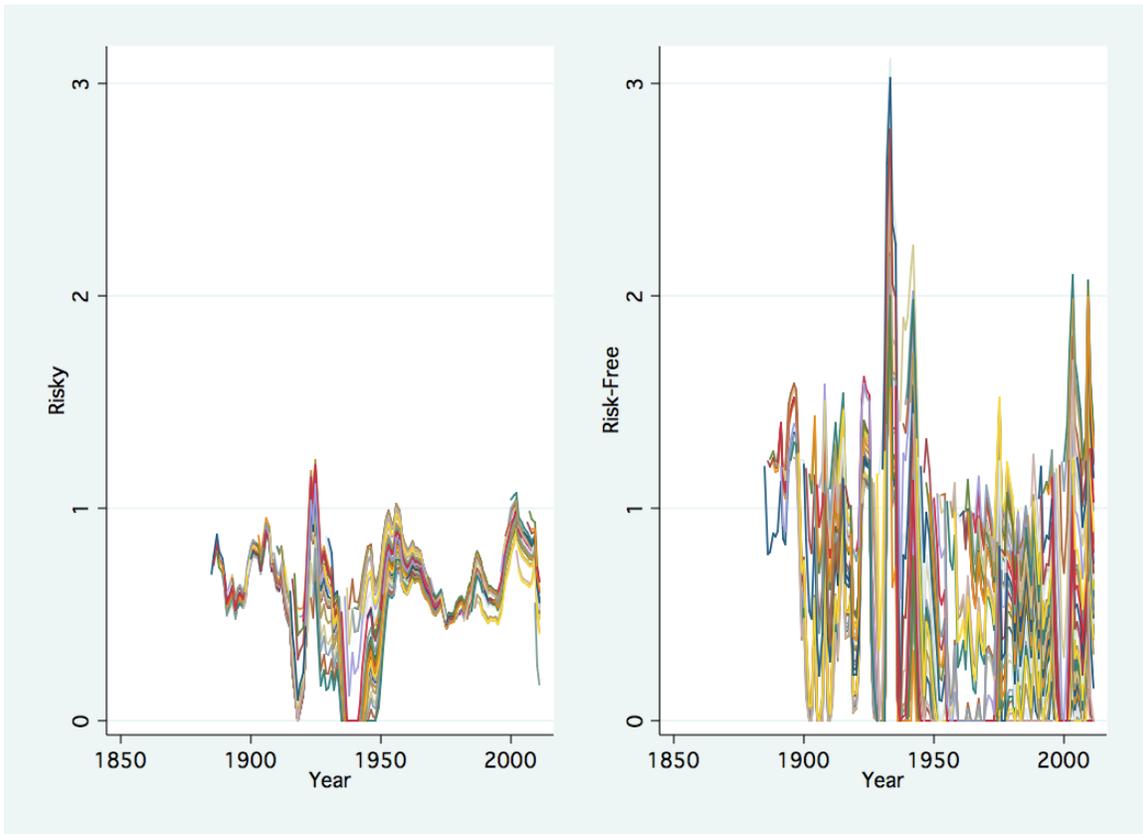
Sources: Louis Johnston and Samuel H Williamson, 'What Was the US GDP Then? MeasuringWorth, 2011'¹³, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller¹⁴, and authors' calculations

Even 'risk-free' pensions that are initially fully funded may be required to make large contributions over time. Figure 8 shows the necessary contributions as a share of payouts in each year for various start years.

¹³ Available from <http://www.measuringworth.com/usgdp>

¹⁴ Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

Figure 8: Simulated Pension Contribution Rates – Fully Funded At Start of Simulation



Sources: Louis Johnston and Samuel H Williamson, 'What Was the US GDP Then? MeasuringWorth, 2011'¹⁵, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller¹⁶, and authors' calculations

Under the risky 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 rule requiring a risk-free discount rate to pay for current benefits exclusively out of contributions. Figure 9 shows the percentage of simulations in which required contributions are zero (green), otherwise less than or equal to payouts (red), and greater than payouts (blue).

¹⁵ Available from <http://www.measuringworth.com/usgdp>

¹⁶ Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

Figure 9: Percentage of Simulations with Zero, Moderate and Large Contributions



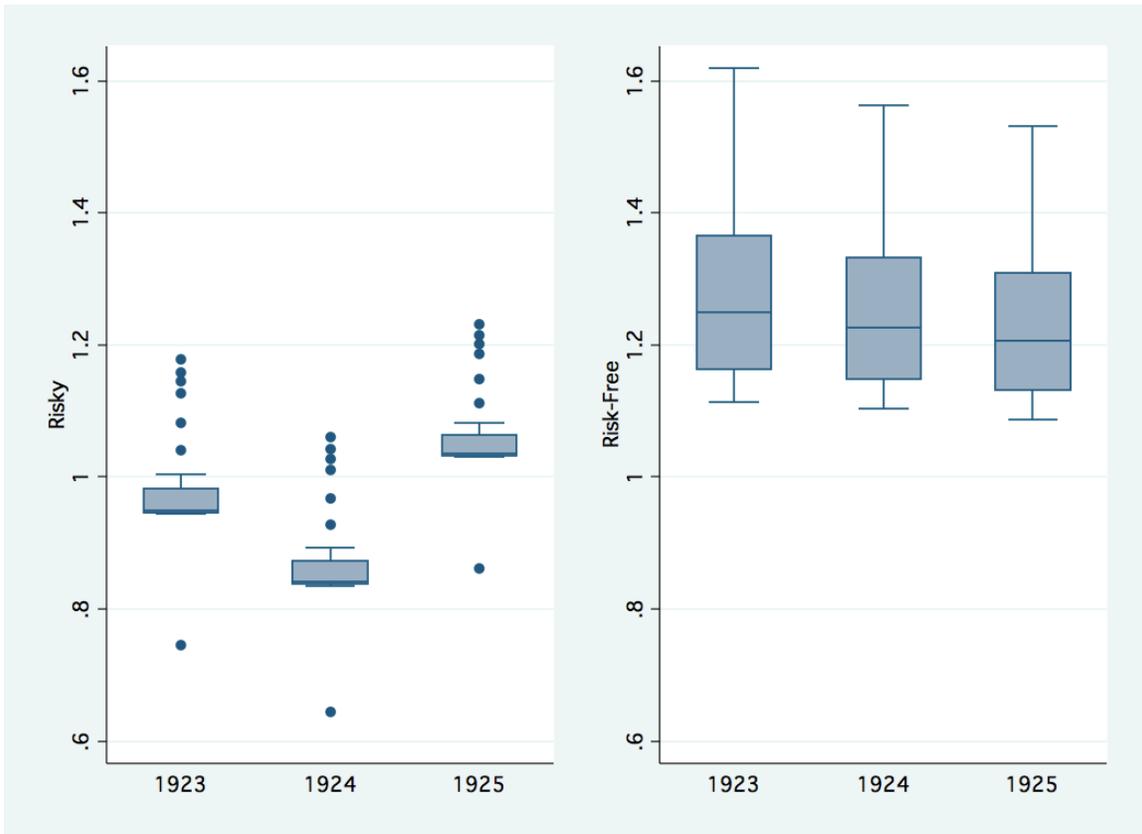
Sources: Louis Johnston and Samuel H Williamson, 'What Was the US GDP Then?' MeasuringWorth, 2011¹⁷, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller¹⁸, and authors' calculations

We can see in Figures 8 and 9 that the worst outcomes under the risky 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 risky-free discount rate.

¹⁷ Available from <http://www.measuringworth.com/usgdp>

¹⁸ Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

Figure 10: Contribution Rates – 1923-25 (Simulations Starting Fully Funded in 1885-1922)



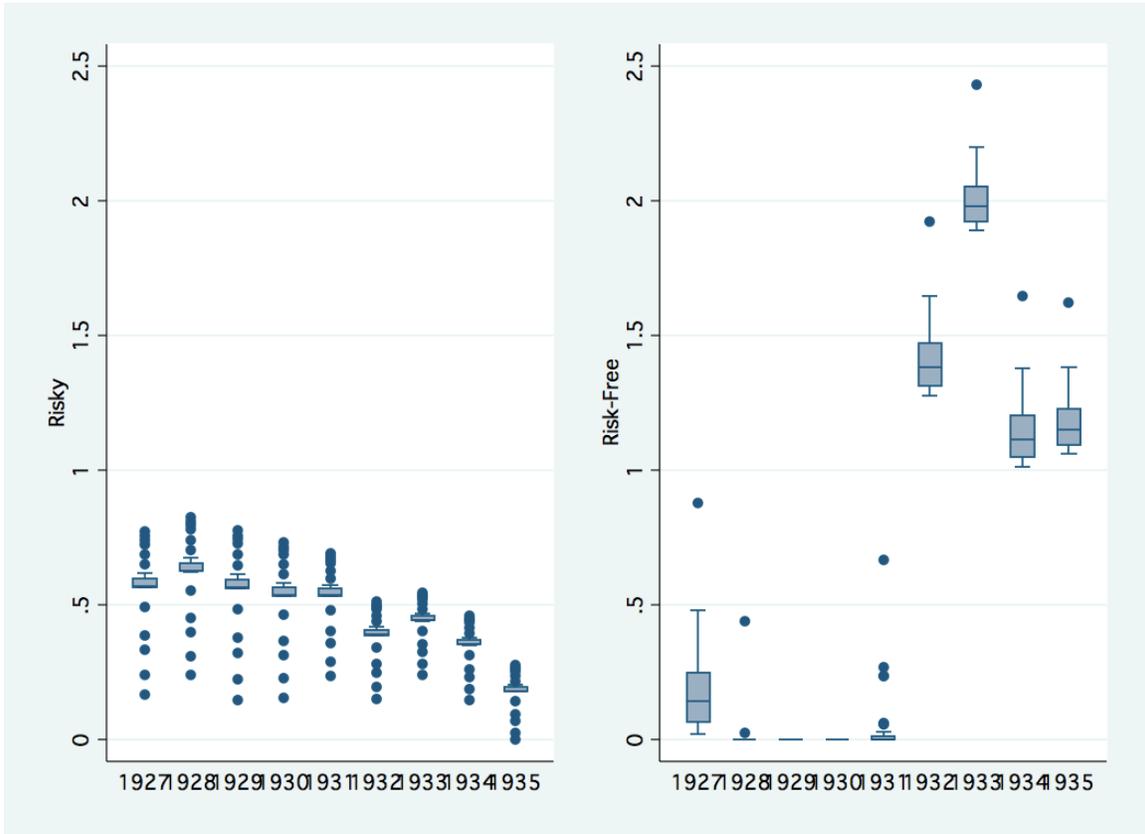
Sources: Louis Johnston and Samuel H Williamson, 'What Was the US GDP Then? MeasuringWorth, 2011¹⁹, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller²⁰, and authors' calculations

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

¹⁹ Available from <http://www.measuringworth.com/usgdp>

²⁰ Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

Figure 11: Contribution Rates – 1927-35 (Simulations Starting Fully Funded in 1885-1926)



Sources: Louis Johnston and Samuel H Williamson, ‘What Was the US GDP Then?’ MeasuringWorth, 2011²¹, Bureau of Economic Analysis National Income and Product Accounts Tables 1.1.5, 1.1.6, and 1.10, Robert Shiller²², and authors’ calculations

Although ‘risky’ 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 fall after the crash. 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 to recognize that the market had subsequently overcorrected and would yield larger returns 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 actual returns in the stock market.

²¹ Available from <http://www.measuringworth.com/usgdp>

²² Available from http://www.econ.yale.edu/~shiller/data/ie_data.xls and <http://www.econ.yale.edu/~shiller/data/chap26.xls>

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 the expected rate of return of the assets held by the fund.

This paper uses data on stock returns dating back to 1990 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 result from stock market crashes like the ones in 1929-30 and 2000-2002.

If the goal of pension fund managers is to maintain a smooth flow of funding and avoiding temporary tax increases needed to meet funding targets, then the 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

An index historical of risk-free returns is constructed from the Shiller ten-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 ten 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 price-to-earnings ratio of 15 over ten 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 ten years. Over the next ten years the PE ratio is assumed to move linearly to a value of 15 in the tenth year after the base year of the forecast. The forecast PE ratio is multiplied by the projected GDP deflator and projected ten-year average real earnings in order to arrive at a price projection.

Dividends are forecast in multiple steps. First, the historical dividend-to-earnings ratio is computed by dividing the average real dividends over the prior ten years by the average real earnings over the prior ten 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 implies a risky discount rate based on the 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 risky.

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 ten 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 'risky' pension is assumed to hold assets sufficient to make it fully funded with respect to the risky 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 risk-free rate.

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