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Funding Soft Liabilities*

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Abstract

Many state and local governments provide subsidized health insurance to retired public employees, but the legal protections that apply to state and local pension liabilities generally do not apply to these other post-employment benefits. Under current government accounting rules that give a role to expected returns on assets, states and local governments use discount rates that increase with the amount of pre-funding. Financial economics, in contrast, implies that viewed from the perspective of taxpayers, cash flows should be discounted at rates that reflect their risk. We estimate RHI liabilities from a taxpayer perspective for the state of California under different assumptions about the extent to which the benefits are defaultable. We then analyze optimal funding strategy in a model in which risk-averse workers who otherwise lack market exposure demand wage premiums to compensate for the possibility of default on retiree medical benefits. More aggressive pre-funding reduces the option value of default but also can reduce the wage premium that must be paid to workers. The model delivers an optimal funding strategy of pre-funding over 15-20 years.

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Governments and firms often have junior liabilities on which they may default in the event of financial distress. Viewed from the perspective of a market participant, the market value of a junior liability declines as the sponsor approaches bankruptcy. If the firm views the liability as a default-free promise plus an option to default, the option to default on the junior liability falls. Offsetting that effect, the holders of the liability claim may demand collateral, flow compensation for bearing the default risk, or both, depending on the type of liability and the institutions that are in place. As a result, the issuer may face a tradeoff. The more he is willing to pre-fund or secure the liability, the less he will have to pay the holders in default risk premiums, but also the less valuable his option to default on the junior liability will be.

In this paper we examine the retiree health insurance (RHI) benefits of state and local governments in view of the fact that they are soft liabilities, junior in most instances to pension promises and many other state liabilities. In addition to pensions, most state and local governments provide these "other" postemployment benefits (or OPEBs) to retired public employees. These promises are largely unfunded, and according to governmental accounting have a present value of around \$630 billion nationwide (Pew Foundation (2012)). However, under governmental accounting, sponsors measure these liabilities using discount rates that depend on the plan's funding strategy. Plans that fund on a pay-as-you-go basis generally use rates of around 4%, whereas the relatively small number that have established a plan to fully pre-fund the promises use rates closer to the 8% historical returns on state government pension assets (Clark and Morrill (2011)).

The basic principles of financial economics imply that viewed from the perspective of taxpayers, cash flows should be discounted at rates that reflect their risk. The 4% discount rates used by many states would therefore be too high to reflect a default-free liability. Importantly, however, the legal protections that impart security to state and local pension liabilities generally do not apply to OPEBs (Clark (2009)).

Taking the state of California as an example, we provide calculations of the present value of RHI liabilities under different assumptions about the extent to which the benefits are defautable. Valued using the risk profile of California municipal bonds, which credits the state for its option to default on the RHI promises in the same states of the world as general obligation debt defaults, the state faces \$87.6 billion of unfunded RHI promises, excluding employees the University of California. Extrapolating to the University of California employees as well as local governments, the present value of the defaultable liability is a largely unfunded $216 billion. These figures are about twice as large if the OPEBs are viewed as non-defaultable promises.

While governmental accounting guides states to use higher discount rates in the presence of more pre-funding, financial analysis suggests that from a taxpayer perspective, more assets backing the OPEB promises makes these less risky for participants, as the value of the state's option to default is reduced when the promise is collateralized by assets. On the other hand, if more aggressive funding strategies leads default to come sooner due to the burden that pre-funding places on government finances, then a more aggressive funding strategy may indeed increase risk. In the realm of state and local government pensions, we observe that governments that have adhered to stricter funding standards that are at least partially binding have had to address pension system imbalances sooner than those that have amassed larger unfunded liabilities as a result of more loose funding standards.[1] A liability valuation framework from a taxpayer perspective would have to take this complex dynamic into account, in essence asking the question what the present value is of expected future tax increases that will be necessary while crediting the government for their ability to default on the debt.

Rather than attempting to incorporate this dynamic into a liability valuation framework, we consider the optimal funding strategy faced by a government in which a default on RHI amounts to the putting of both assets and liabilities to the beneficiaries. This structure is consistent with defaults on RHI observed in the private sector. The primary examples of this are the Voluntary Employee Benefit Associations (VEBAs) established in 2007 through separate agreements between the United Auto Workers (UAW) union and the Detroit Three auto makers (General Motors, Ford, and Chrysler).

In our model, rational risk-averse government workers who do not save or trade on their own accounts demand wage premiums to compensate for the possibility of default on retiree medical benefits. This approach builds on papers that have considered compensating differentials firms sponsoring risky defined benefit (DB) pensions might have to pay to employees (Sharpe (1976), Bodie (1990), Love, Smith, and Wilcox (2007, 2011)). Our model departs from this

[1] As an example of this effect in pensions, we compare the cities of San Diego and San Jose, which regularly contributed 100% of the actuarially required pension contribution from 1996 through 2009, with the city of Chicago which regularly contributes a much smaller fraction of the actuarially required contribution. The political will to enact pension reform in San Diego and San Jose is likely to have emerged because the city's pension contributions were a large share of the budget under its own rules. The political will in Chicago has been elusive in no small part because the state's own rules allow it to contribute less than the amounts needed to bring the system back into balance.

literature in that the employees are represented by a lifecycle utility agent as opposed to agents who subsist for two periods. Furthermore, defaults are triggered by the relationship between government expenditures and stochastically evolving government revenues. We consider optimal funding strategy in this dynamic context.

Since employees with standard relative risk aversion preferences in a lifecycle model prefer smooth consumption, they would charge an extra premium for consumption that is variable from period to period, other things equal. However, the employees in our model also start out bearing no market risk, and with a positive market risk premium, they will *ceteris paribus* prefer a contract that gives them some market exposure. We treat government revenues as having a priced, market-correlated component, and defaults as occurring when revenues fall below a threshold of expenditures. Employees therefore can obtain market exposure directly through the correlation of the default state with the market, as well as well as through the medical fund assets if they are invested in equities.

We consider funding strategies that involve paying down unfunded liabilities over a given number of years (from 1 to 100). As the pay-down period gets large it becomes asymptotically equivalent to the defaultable pay-as-you-go strategy that most governments currently employ. For each possible funding strategy, we solve for the wage premiums that would make employees indifferent between a hypothetical binding default-free benefit and the risky package of benefits the government is offering. We then calculate the total cost of providing the benefits under each of these possible funding plans.

The results show that the employees' desire for consumption smoothing and market exposure deliver an interior solution for the amortization period. That is, there is an optimal period over which the government should attempt to pay down unfunded liabilities, recognizing that shorter paydown periods raise the likelihood of early default but also increase the employees' recovery conditional on default. In most specifications, this optimal pay-down period is 15-20 years and is less costly to implement than continuing pay-as-you-go (PAYG) funding until the default boundary is crossed, again assuming that employees rationally require risk premia to make them indifferent between the given strategy and what the benefits would be if the government could commit to providing them.

I. Retiree Health Insurance in the Public Sector

While RHI has largely been eliminated from the balance sheets of US corporations, it is still quite common in the public sector and is even offered to new government hires in most instances, as a benefit the state promises the employee will in retirement. The Employee Benefit Research Institute (2012) reports that in 2010 only 17.7% of private-sector workers were employed at establishments offering RHI to early retirees and 15.9% at establishments offering RHI to Medicare-eligible retirees. In contrast, in the public sector, between 2006 and 2010 the percentage of large local governments offering RHI to early retirees was 77.6% and the percentage offering it to Medicare-eligible retirees was 67.3%. While these rates have fallen in both the public sector and the private sector, they have fallen more rapidly in the private sector.

The typical governmental RHI plan covers two sets of expenses. First, most public RHI plans give retirees continued access to subsidized health insurance between the employee's retirement date and eligibility for Medicare at age 65. Second, while some state and local governments terminate coverage when the retiree reaches Medicare eligibility at age 65, other states offer Medicare-eligible retirees over the age of 65 coverage for benefits beyond what Medicare covers, including premiums, deductibles and copays.

Clark and Morill (2010, 2011) provide extensive overviews of these benefits. The retiree health expenses incurred by the public entity fall into two conceptual categories: explicit subsidies and implicit subsidies. Explicit subsidies are the amount that the state or local government pays for the premiums. Implicit subsidies reflect the fact that the insurance premiums are generally priced using pools that include active workers, who are substantially younger than retirees. As explained by Clark and Morrill (2011), even a state government that charged retirees 100% of the premium would still be providing an implicit subsidy if the rates at which the retiree is paying are rates determined by pooling together the young, less expensive active workers and the older, more expensive retirees. According to the US Government Accountability Office (2007), as of 2006 there were 14 states (including Indiana, Wisconsin, Washington, and Oregon) that provided no employer contribution for coverage, so that the state's entire RHI liability is an implicit subsidy, while another 14 states (including Illinois, California, Ohio, and Texas) paid the entire cost at least for some employees, with the remaining 22 states falling somewhere in between.

Employees generally become eligible for retiree health benefits only after they have accumulated a certain minimum number of years of service. Other eligibility requirements vary by state. In some states, including California, vesting is graded, with the percent of the premium paid by the state calculated as a function of the number of years of service. Furthermore, there may be a requirement that the employee retires and starts collecting a pension directly after leaving service. For example, in California a retiree must actually receive a retirement allowance (pension) from the state and must begin doing so no more than 120 days after leaving employment. In this instance, the state has no RHI liabilities owing to workers who "separated" from employment more than 120 days ago. Clark and Morrill (2010) provide a comprehensive overview of the plans offered by state governments.

The availability of retiree health benefits are often viewed as an important part of the compensation package for public sector employees. Furthermore, the availability of retiree health benefits may provide incentives for public employees both to remain in public employment until retirement and to retire at comparatively young ages (Blau and Gilleskie (2001), Clark and Morrill (2010)).

In some respects the measurement and funding issues surrounding deferred compensation in the form of RHI mirror those of state and local government pension systems (see Novy-Marx and Rauh (2009, 2011)). One major difference between retiree health promises and pension promises, however, is that while most states have statutory and/or constitutional protections for pensions (Brown and Wilcox (2009)), retiree health benefits do not have similar status (Clark (2009)). Furthermore, Shnitser (2012) documents that most states have constitutional provisions regarding the funding or governance of pension systems. These protections do not exist for RHI, nor is RHI generally viewed as a vested right protected by contract law. Collective bargaining arrangements and the value that employees attach to RHI are generally viewed as the primary limits on the ability of states to modify or even terminate health benefits for retired public servants.

Mendel (2012) cites several current examples of the ability of financially distressed cities to cut RHI. The city of Vallejo, California, in bankruptcy proceedings that ran from 2008 to 2011, reduced retiree health care payments by approximately 80% as part of the reorganization. The city of Stockton, California, has proposed ending all retiree health payments, citing an accrual cost of offering the benefit equal to over 30% of total payroll, amounting to savings of approximately $400 million.

The notion that cities and states can drastically cut RHI in financial distress raises the question of what actual event can be viewed as triggering default. Pension systems provide an interesting lens on the triggers of reform, as cities' experiences with pensions suggest that often it is the burden on the budget of the funding plan in place that provides an impetus to change some of the rules, at least on a forward-looking basis. While pension promises enjoy legal protections that greatly limit the potential for the revocation of any benefits, pension systems have at least been reformed for new employees in cities such as San Jose and San Diego, where pension contributions were consuming over 20% of revenue from governmental activities.

Figure 1 illustrates the dynamic in in San Jose and San Diego as compared to another city, Chicago. Both San Jose and San Diego have consistently contributed 100% of the actuarially required contribution (ARC) for pensions. By holding themselves to a standard where they were both paying the present value of new pension promises and paying down unfunded liabilities, they each ended up in a situation where following that rule became too much of a weight on public finances to be politically sustainable.

In contrast, the city of Chicago has followed their own funding rules, which have diverged from the funding that actuaries have recommended as needed to pay the present value of new promises and pay down unfunded liabilities. As a result, pension contributions as a share of Chicago's governmental activity revenues have remained flat at around 10%, while the actuarially recommended contributions have risen to 35%. But because the impact has not yet been felt on the budget, in large part due to the city writing its own rules, the political momentum for pension reform has not yet gained steam.[2]

This analysis suggests that more rigorous funding standards for RHI may in fact lead to a default sooner than would otherwise happen, albeit with a higher funding level in place in the event of default. How might RHI promises be unwound? The private sector, and in particular the automobile industry which carried large unfunded RHI liabilities, provides one possible outcome. In 2007, agreements between the United Auto Workers (UAW) union and the Detroit Three automakers (General Motors, Ford, and Chrysler) established a stand-alone voluntary

[2] Similarly, during the Vallejo bankruptcy, the city did not alter accrued pensions but did change benefits for new workers. Vallejo participates in the California Public Employees Retirement System (CalPERS), which required enough contributions in the past to keep the present contributions requested by actuaries from rising to the extent experienced in San Diego and San Jose. CalPERS argued that its contracts remained in force despite the bankruptcy, and the outcome of the Vallejo bankruptcy was actually an increase in annual payments to CalPERS (Mendel (2011)).

employee benefit association (VEBA) for the purpose of defeasing the liability. The assets and liabilities were transferred to the VEBA, and the future liabilities of the automobile company were limited to assets, securities and future contributory amounts agreed upon the establishment of the VEBA entity. As such this was a "defeseance" VEBA as opposed to the more traditional company-run arrangements (Moore (2008)). The VEBA provides no guarantee that benefits will be fully paid.

In the years leading up to the UAW VEBA agreement, the car companies had spent large amounts of money on retiree healthcare. By one estimate, retiree health costs alone added $1,045 to the average cost of a GM vehicle, and the Detroit Three automakers had a total of more than $100 billion in long-term retiree health liabilities on their books (Bernstein (2008)).[3] The 2007 agreement for the VEBA involved up-front funding of $30.2 billion by GM, including $16 billion was a transfer from GM's own medical fund and a $4.4 billion convertible bond. The total commitments by the three companies have been estimated at $54 billion, leaving the fund assets considerably short of total liabilities, although a 9% annual return assumption allowed the parties involved to consider the VEBA close to fully funded (Bernstein (2008)). By 2009 the UAW VEBA had formally separated itself from the automakers, so that its only formal options for dealing with unfunded liabilities were changes to benefits, increases in employee premiums, or requests to the car companies for further assistance in exchange for other concessions (Terlep and Dolan (2011)).

In the optimal funding calculations in this paper, we proceed by assuming that default occurs when the revenues generated by the government fall below a certain threshold ratio of revenues to expenditures. At that point, the government defaults by putting the assets and liabilities into the ownership of the employees in a VEBA-type arrangement. We recognize that there are a number of different channels and methods through which benefits could be reduced. Specifically, governments can shift to a defined contribution arrangement; they can reduce the percentage of the insurance premiums that they pay; or they can tighten the eligibility requirements to qualify for retiree health benefits. The US Government Accountability Office (2009) reports that changes to the level of government contributions have been most prevalent. This echoes the findings of Daley and Coggburn (2008), who report that as of that time a majority of state governments asserted that they were unlikely to adopt a VEBA; 66% had

[3] General Motors had measured $47 billion of liabilities at a 6% discount rate.

increased retiree contribution premiums and many had also increased retiree deductible amounts and coinsurance rates. Similarly, Clark and Morrill (2010) report that 16% of states have increased the years of service for vesting in the past 5 years, 72% have increased retiree contribution premiums, and 51% have increased retiree deductible amounts.

In this paper, we take the view that the conversion of defined benefit RHI into standalone VEBAs and other defined contribution arrangements will become more common as the magnitude of unfunded RHI liabilities becomes more apparent, especially in the state of the world where governments are faced with the prospect of defaulting on a range of obligations. Indeed, a number of governments, including New York City and the state of New Hampshire, have already implemented various types of retiree medical trusts which could ultimately be converted to standalone defined contribution arrangements. It also seems plausible that the qualitative conclusions of our model would be similar for a gradual soft-default through the reduction of retiree benefits in the event of increasing government budget deficits.

Another possibility that has been raised is the possibility of using state health exchanges created under the Affordable Care Act as a potential source of insurance for retirees, as this can service as an alternative to employer-provided coverage (Scott (2012)). A city of Chicago commission has suggested ending coverage for all retirees as soon as these exchanges are available under the Affordable Care Act (Retiree Healthcare Benefits Commission (2013)). Such a change would leave employees buying their own insurance, but employees would not experience as complete a default as we model since the federal government will provide subsidies for insurance bought on the exchanges.

Finally, the taxation of retiree health benefits is an important consideration for our study. In most current arrangements, the individual faces no tax liability for premiums paid by the employer for retiree health benefits.[4] The stream of cash flows from RHI premiums are therefore more similar to a tax-exempt bond than to a taxable bond, unlike pension payments which are always subject to federal taxation and can be subject to state taxation as well depending on the state.

Premiums paid by the retiree are generally paid out of after-tax dollars, however. It is well known that active employees can generally elect to reduce taxable wages in order to pay health insurance premiums with pre-tax dollars. However, this "premium conversion" is not

[4] Operationally, employer-provided RHI premiums are often deducted from pension checks.

available to retirees, other than certain retired public safety officials who can deduct up to $3,000 of qualified health insurance premiums from their pensions on a pretax basis (Mulvey (2011)). There are tax advantages of setting up governmental trusts, in that the investment returns on the funds are not taxed. Furthermore, VEBAs that can accept both employer and employee money would allow employee contributions for health insurance premiums to be made on a more tax efficient basis.

II. Measurement of Retiree Health Promises with California Example

Governmental accounting standards for RHI were formalized in Governmental Accounting Standards Board (GASB) Statement 45 in 2004. The method recommended in this GASB statement uses expected returns on assets to measure liabilities, which in a number of ways parallels the accounting for pensions. As explained in Novy-Marx and Rauh (2009, 2011), discounting liability cash flows using expected returns on assets approach is analytically misguided: the magnitude of pension liabilities and how a pension's funds are invested are two entirely separate issues. Standard financial theory suggests that financial streams of payment should be discounted at a rate that reflects their risk, and in particular their covariance with priced risks.

The technique of "expected return discounting" has a number of perverse implications. For example, pension debts can be made to appear much smaller by taking more risk in the asset portfolio (Novy-Marx and Rauh (2009)). Furthermore, as explained by Novy-Marx (2013), a dollar of stock would appear to be worth more to a pension system than a dollar of bonds; burning safe securities can positively affect funding ratios; and dividing or combining pension plans can change the apparent funding levels.

Measuring the present value of the cash flows as a promise requires the use of default-free rates, as the cash flows are analogous to those on a non-defaultable bond. If the pension benefit is defaultable, then one could justify using the yield on a defaultable bond at least from the perspective of a taxpayer interested in the present value of additional taxes that will have to be raised to cover benefits. So for example, if the pension promise is analogous to a municipal bond and the pension promise will be defaulted upon in the same states of the world and with the same recovery rates as the bond, then a present value of the liability cash flows using state municipal yield curve would represent the present value of expected future benefit payments. Of course, discounting at state-specific municipal rates has the undesirable feature of generating lower stated liabilities if a state's credit rating worsens.

It is important to emphasize that these measurement considerations are separate from the derivation of optimal funding rule, which would have to take into consideration the desirability of transferring money between present generations and future generations of taxpayers, between public employees and taxpayers, and across different states of the world. Related to the example in the previous paragraph, a funding rule that paid the present value of new benefit promises using the yield on the state's own bonds would have the perverse property of funding the pension promise to a lesser extent if the state's credit rating deteriorated.

Before 2004, states generally just viewed their RHI promises on a PAYG basis. The costs the state reported were simply the costs of paying benefits in the current year, and no present value liabilities were calculated. GASB 45 then established accrual accounting as an important concept: benefits become liabilities as they are earned, and there is an ongoing cost of promising benefits to current workers that may be higher than the current cash cost of paying out benefits to retirees. In that sense, GASB 45 made the measurement of RHI promises more like that of pensions.

The GASB 45 guidelines for measuring RHI liabilities differ from those for pensions in some important ways. GASB recognizes that many RHI promises are not in fact pre-funded, in which case there is no "expected return" on the assets that can be applied. If the government is continuing to use a PAYG approach to paying for the RHI benefits, it is supposed to use the expected returns on the employer's general (not pension) fund assets, which are generally invested quite conservatively. Today's money market funds and other deposit-like investments pay at most 1%, but the discount rate for unfunded liabilities is typically around 4%. If the government is targeting a fully funded system over a specified period of years, then the government will apply a full expected return on assets, generally in the region of 7.5-8% per year, justified by the historical realized return on pension funds that have invested in a roughly 60/40 mix of diversified stocks and bonds. If the government is targeting a partially funded pension system over a specified period of years then they will use an intermediate rate between the short-term general fund expected return and the long-term expected return on assets.

Another measurement issue relates to what promises are recognized as a liability. There a number of different ways to measure what benefits have actually been accrued by an employee at any given time. This issue is best illustrated with an example. Suppose a 55 year old employee has worked for a state government for 9 years and will vest in his pension and become eligible for early retirement with retiree health insurance in one year, when he has completed 10 years of service. The most narrow possible view of the state's obligations considers only benefits that have been technically earned. This narrow view would say that as of today the state does not yet owe the 55 year old employee any pension or retiree health obligations. In theory, the state could fire the worker within the next year, or could implement a freeze of all benefits immediately which would amount to this worker receiving no benefits since technically as of now he has not earned any. The narrow view is commonly referred to as an *accumulated* obligation.

In contrast, a broad view of the obligation would say that the state would likely face high legal costs in attempting to implement such changes, and that probabilistically it is quite likely that the employee will work for another year and become eligible for the pension and retiree health benefit. This broader view would therefore view the liability as equaling the present value of expected future payments that will be owed to the employee if his future work and life trajectory follows the averages calculated by actuaries and if the plan is left in place. This calculation is commonly referred to as a *total* liability, expected liability, or present value of benefits.

Between the accumulated obligation and the total liability there are various concepts of accrued liability, such as those that apportion the accumulation of the total liability in equal steps over the career of a worker even if the benefit is not technically earned until a particular future year. One variant of this is the Entry Age Normal Actuarial Cost Method which produces a flow cost of the benefit that is a level percentage of the employee's pay. This is the method used by the state of California in the calculation of its annual accrual costs for RHI.

Table 1 summarizes some of the key disclosures made by the state of California for its retiree health liabilities costs. The California Public Employee Retirement System (CalPERS) administers the California state OPEB plans. CalPERS consists roughly of one-third general state employees, one-third non-teacher public school employees, and one-third city and county employees whose employers contract with CalPERS to provide benefits. However, CalPERS only offers RHI to the first group, the general (non-school) state-employees. Table 1 includes all of these members other than judges and legislators, a total of 257,175 active employees and

150,973 retirees.[5] PV of Liabilities (Accrued) is the present value of the benefit cash flows attributed only to employee service earned in prior fiscal years. PV of Liabilities (Total) is the present of the expected cash flows for current employees and retirees.

Although California uses PAYG almost exclusively for RHI, the state discloses the present value liabilities and the accrual costs (which can be thought of as the annual change in the present value liabilities) under three different discount rates: the PAYG rate of 4.5%, a partial funding rate of 6.055%, and a full-funding rate of 7.610%. Unfunded accrued liabilities are \$40.4, \$49.3, and \$61.6 billion respectively under the different discount rates in decreasing order (7.61%, 6.055%, and 4.5%). Total unfunded liabilities based on expected cash flows are \$49.8, \$64.6, and \$87.1 billion respectively using the different discount rates.

In contrast to the GASB rules, financial economics is clear that the value of the RHI benefits as a promise should be measured using risk-free rates, and the market value of the benefits that are expected to be paid should be measured using rates that reflect the correlations of the benefit cash flows with priced risk factors. The rates chosen by California which are justified by expected returns on assets are therefore not economically meaningful. However, the fact that the disclosure is given under the three different rates is useful, as it allows for an approximate measure of the modified duration of the liabilities:

$$ln\left(\frac{L_{r(i)}}{L_{r(j)}}\right) = D^{*} ln\left(\frac{1 + r(i)}{1 + r(j)}\right) \tag{1}$$

where $r(i)$ is one of the discount rates and $L_{r(i)}$ is the liability using that rate. For $r(i)$ = 6.055% and $r(j)$ = 4.500%, the modified duration of accrued liabilities is 15.1 and the modified duration of expected liabilities is 20.2. For $r(i)$ = 7.610% and $r(j)$ = 6.055% the modified duration of accrued liabilities is 13.8 and the modified duration of expected liabilities is 17.8. The durations give a first-order approximation of the percent change in liability value for a one percentage point change in the discount rate.

The report by the Public Employee Post-Employment Benefits Commission (2007) provides evidence that the liabilities represented in Table 1 in fact represent only around 40.5% of the total state and local OPEB liabilities in California. This is because RHI plans are also sponsored by the University of California as well as by hundreds of cities, counties, and

[5] There were 3,256 retired and active judges and 124 retired and active legislators who are not included in this total.

districts.[6] Table 2 documents this fragmentation by showing the total number of employees for the state plans plus the largest local plans. Of the plans shown, only the City of Los Angeles is pre-funding, contributing an amount that is greater than (or even close to) the accrual cost of new benefit promises. As a result, the City of Los Angeles contributes 8.8% of revenues to these plans, far more than the contributions of the other entities shown.

In order to re-estimate the liabilities of the California state plans at discount rates that reflect their risk, we first reverse-engineer the cash flows whose discounted value equals the present value reported by the state in CalPERS (2011). Note that we cannot rely on simple duration relationships because the appropriate discount rates are actually yield curves, so the actual stream of cash flows is required. Once obtained, the stream of payments can then be re-discounted using alternative yield curves. Formally, define $L_{i,stated}$ as the total liabilities that a given plan i reports, and define $r_{i,stated}$ as the flat discount rate that the plan reports it uses. Plans discount cash flows using a simple discounted cash flow formula:

$$L_{i,stated} = \sum_{t=1}^{T} \frac{C_{i,t}}{(1 + r_{i,stated})^t}. \tag{2}$$

However, plans do not report – and are generally unwilling to release – the cash flows ($C_{i,t}$), which appear in the numerator. They do, however, provide extensive detail of the age and cost structure of the retiree health benefits.

We use the following procedure to reverse-engineer the cash flows. The inputs are the cost of the most recent benefit takers; the number of benefit recipients under 65 years old; the number of benefit recipients over 65 years old; the retiree age distribution provided by the plan; the mortality rates provided by the plan; the premium caps specified in the plan; and the health cost inflation assumption that the plan is using. Since Medicare pays part of older workers costs, older workers are less expensive than younger workers.[7] We then forecast future benefit payments as a function of the unknown benefits for the under-65 retirees, subject to the constraint that the unknown under-65 retiree benefits plus the unknown over-65 retiree benefits

[6] As of 2006 when the data for the public employee post-employment benefits commission report were collected, state liabilities at the PAYG rates were $47.9 billion (compared to $61.6 billion today) and liabilities across all state plans at their chosen rates were $118.1 billion, for a ratio of 40.5%. The only way for the commission to obtain the total aggregate number was to conduct a one-time survey every state and local government in California. The report cites 198 cities, 53 counties, 188 special districts, and 39 community college districts that sponsor these plans, in in addition to the state of California and the University of California.

[7] They also have fewer dependents.

equals the known total cost. Finally, we conduct a search over the grid of under-65 costs, minimizing the root mean squared deviation (in percent) of the model's NPV from the stated liabilities.[8]

Figure 2 shows the cash flows we derive. These are cash flows associated with total expected liabilities, not only accrued liabilities. Current expenditures of $1.7 billion are completely for today's retirees. As those retirees get older, some of them die and some of them become less expensive because they become eligible for Medicare. As the active workforce begins to retire, the total payments increase, peaking at over $6.5 billion in the mid-2040s. This is a closed-group analysis, so no workers hired after 2011 are included.

We examine these liabilities under three different yield curves: the California state tax exempt general obligation municipal bond yield curve, a California taxable municipal yield curve, and a Treasury yield curve, all priced as of December 31, 2012. These yield curves are shown in Figure 3. The California state tax-exempt curve and the Treasury curve are from Bloomberg. The taxable muni is imputed using a 25% marginal tax rate, based on Poterba and Verdugo (2011) who present evidence that the tax rate implied by muni bond prices is approximately of this magnitude.

Discounting the expected RHI benefits at the California tax-exempt municipal yield curve prices the RHI obligations as though they were California government bonds with tax-exempt coupons. Note that both the coupons on state general obligation bonds and the employer premiums paid for RHI are tax-exempt, so the tax treatment of these two instruments is similar. From a risk perspective, the use of the California tax-exempt curve treats the RHI payments as though they will be defaulted upon in the same states of the world and with the same recovery rates as California state bonds. We find that the market value of the unfunded California state RHI promises under the California state tax-exempt municipal yield curve is $87.6 billion, coincidentally quite close to the present value using a flat 4.5% discount rate for all obligations. A little over 60% of this liability is owed to currently active workers.

Discounting using the yield curve on defaultable debt may approximate the market value of the unfunded RHI as far as taxpayers are concerned, but it under-represents the cost of

[8] Note that we conduct this procedure separately for the 7 sub-components of the state plans: the California State University employees, the State Miscellaneous Employees excluding Cal State, the State Industrial Members, the State Highway Patrol, the Cal State Police and Fire Officials, the Police and Fire Officials excluding Cal Stat; and All Other State Safety Officials.

providing RHI without default. If the state actually wants to guarantee the benefits – that is, if it does not want credit itself for its option to default on the benefits – it would have to use a default-free yield curve such as a Treasury curve. Discounting the RHI cash flows using the Treasury yield curve results in total unfunded liabilities of $121.6 billion. Since this is a total expected liability calculation, it assumes the current RHI plans that are in place will apply to the entire current workforce and not altered. Note that the Treasury curve is the yield on a bond with taxable coupons; a stream of cash flows that represented a default-free, tax-free guarantee would require an even lower rate.

Table 3 also shows that using a taxable California state yield curve, the unfunded liabilities are $66.2 billion, or $21.4 billion less than using the tax-exempt yield curve. In other words, the fact that the benefits are tax-free makes them $21.4 billion more valuable than if they were not. Indeed, for the promise to be defeased, the state or an insurance company would have to deliver tax-exempt, not taxable bonds, which would be more expensive by this amount.

The above analysis ignores the feedbacks that may exist between funding strategy and the default likelihood and recovery rates in default. From a taxpayer perspective, more assets backing the OPEB promises makes the OPEB promises themselves more valuable, as the value of the state's option to default is reduced when the promise is collateralized by assets. On the other hand, if more aggressive funding strategies leads default to come sooner due to the burden that pre-funding places on government finances (as shown in the previous section), then a more aggressive funding strategy may increase risk and reduce the value of the promises.

A complete liability valuation framework from a taxpayer perspective would have to take this complex dynamic into account, in essence asking the question what the present value is of expected future tax increases that will be necessary while crediting the government for their ability to default on the debt. Rather than attempting to incorporate this dynamic into a liability valuation framework, we consider the optimal funding strategy faced by a government in which a default on RHI amounts to the putting of both assets and liabilities to the beneficiaries.

III. Modeling the Trade-Offs Between Pay-As-You-Go and Pre-Funding Strategies

We consider optimal funding strategy in a model in which the government can default and put the shortfall in the medical fund to employees. The default occurs when the ratio of revenues to expenditures falls below a specified threshold. At that point, medical benefits are reduced to the level supportable by the medical fund assets. Employees require wage premiums to compensate for the probability of default. The government must pay them wages that equalize the utility of the compensation package with risky and riskless benefits.

This approach is related to the literature that has examined optimal pension funding behavior by corporations who have an option to offload pension liabilities in the event of bankruptcy. Before ERISA law of 1974, this option was essentially to put the pension assets and liabilities to employees in the event of bankruptcy. As Sharpe (1976) points out, if capital markets are complete, workers will demand a wage premium equal to the value of this put option that they are providing to the firm.

The ERISA law then established the Pension Benefit Guaranty Corporation (PBGC) as a government entity which insures defined benefit pension obligations for private sector employees up to certain annual limits. The PBGC provides this insurance explicitly to firms in exchange for premiums, and firms must also follow government regulations concerning pension measurement and funding. Since then the put option has become largely one that is written by the PBGC rather than by employees, although employees still face some risk if they are above the PBGC limit, which in 2013 stands at $57,500 per employee per year. Marcus (1987) values this put option in an options pricing framework, generally finding that with free insurance and absent tax benefits of pre-funding, minimal funding is optimal. An extra dollar of pension funding reduces the value of the firm's put option by less than one dollar.

Our model to some extent draws on the concepts in the models of corporate defined benefit (DB) pension funding by Love, Smith, and Wilcox (2007, 2011). They argue that when employees cannot hedge firm-specific risk, corporate sponsors of DB plans have an incentive to fully fund the plans with bonds, as this strategy will minimize the total benefit cost inclusive of wage premiums demanded by the risk-averse workers (Love, Smith and Wilcox (2007)). When there is partial and underpriced pension insurance, however, firms may have an incentive to maximize risk by reducing pension contributions and mismatching assets and liabilities (Love, Smith and Wilcox (2011)). Our model departs from this literature in that the employees are represented by a life-cycle utility agent, as opposed to agents who subsist for two periods. Furthermore, defaults triggered by the relationship between government expenditures and stochastically evolving revenues. This allows the determination of an optimal period over which to pay off the liability.

In our model there are three primary factors at work. First, pre-funded amounts cannot be recovered by the government. Hence for a liability of a given size, the larger the assets in the medical fund, the greater the recovery rate of employees will be in default and hence the lower the government's option value to default. Second, an aggressive pre-funding strategy will allow for earlier default, as it contributes to the imbalance between revenues and expenditures and enhances the political will to alter benefits. Third, pre-funding affects the wage premium for risk-averse workers. Generally the more assets the employees expect to have in the fund when they assume the assets and liabilities, the smaller the wage premium needs to be to compensate for default risk. However, since very aggressive pre-funding strategies can push the government into default more quickly, it is possible that government attempts to pay down the liability too quickly could lead to increases in wage premiums.

A representative worker who plans to retire at date R will have utility at t=0 equal to

$$U = \sum_{t=0}^{R} \beta^t S_{a,a+t} \frac{\left[(w+M)^{1-\gamma}\right]}{1-\gamma} + \sum_{t=R}^{\infty} \beta^t S_{a,a+t} \frac{\mathrm{E}\left[(0.6w+HP+M)^{1-\gamma}\right]}{1-\gamma} \tag{3}$$

where β is a discount rate, $S_{a,a+t}$ is the probability that the employee survives form age a today to age $a+t$, w is the employee's wage, M is his medical benefit during work and also in retirement, HP is the value of home production, and γ is the coefficient of relative risk aversion.[9] The first term represents the expected utility the individual receives while working and the second term represents the utility he receives while retired. As is clear from the above equation, these plan participants consume all their income each period – they do not save. Thus, a compensation package that delivers smooth consumption for them will be cheaper for the government employer than one that delivers variable consumption. That said, they have no market risk, so that given their utility function, compensation packages that provide some market risk will be attractive to them for a sufficiently high market risk premium given their risk aversion.

We examine three possible strategies: 1.) binding non-default, even though it may be impossible for the government to commit to this; 2.) unfunded PAYG with zero recovery if default is triggered, and 3.) amortized pre-funding over a period of years, with the beneficiaries recovering fund assets when the default is triggered. We examine pre-funding amortization

[9] When γ equals one the one-period felicity is given by the log of consumption.

periods of 1 to 100 years, so the third strategy really consists of 100 different possible strategies. In studying the amortized pre-funding strategies, we assume that the government can in fact commit to amortized funding over a period of years as long as the default threshold is not triggered.

Specifically, we model amortized pre-funding starting from the currently common point of completely unfunded liabilities. For a pre-funding strategy spread over N years, the government contributes fraction $(1\text{-}f)/(1\text{-}f^N)$ of $(1+r)^N L$, where L is the default-free present value of today's liabilities, and f is the ratio of the gross growth in expenditures to the gross default free discount rate, i.e. $e^{g(exp)-r}$. This setup amortizes the unfunded liability by contributing a constant fraction of revenue, until the moment of default.

We calibrate the baseline scenario of the model using the assumptions in Table 4. The risk aversion parameter γ is 1 in the baseline (log utility), but we also examine values 0, 2, and 5. The Market Risk Premium (MRP) is the excess return on the market over the risk free rate. It is 0.06 in the baseline and we also examine lower values in other scenarios. All of the discount rates and growth rates are in real terms, so the starting wage value of 50 is constant in real terms throughout the simulation, as is the initial medical benefits value of 12 and the home production of 20.

The growth rates, volatilities, and factor loading assumptions about government revenues and expenditures are broadly calibrated roughly to California, based on historical data through 2012 from the California Legislative Analyst's Office website.[10] In 2012, state government revenue generated in California from all non-federal sources was approximately \$121 billion, and expenditures were \$213 billion, with most of the difference explained by revenue from the federal government to the state.[11] This represents a current ratio of revenue to expenditures of 0.57. Our baseline default assumption is that the state defaults on the medical liabilities when this ratio falls below 0.5. In essence the modeling is equivalent to assuming that the federal government will only pay up to half of the state's total expenditures before the state is forced to default on some obligations.

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[10] http://www.lao.ca.gov/laoapp/LAOMenus/lao_menu_economics.aspx

[11] Revenues consist of revenues for both General Fund and Special Fund. They include Major Revenue, Minor Revenue, and Transfers & Loans. Expenditures also consist of General Funds, Special Funds, Federal Funds, and Bond Funds.

Figure 4 shows the historical levels of revenues, expenditures, and the Fama-French excess return index. The excess return index is normalized to a value of 1 in July 1926, so that the value at time t equals $\Pi_t[1+(r_{m,t} - r_{f,t})]$. The continuously-compounded mean nominal historical growth rates of revenue and expenditures respectively since 1985 have been 5.0% and 5.8%. Their volatilities have been 6.5% and 4.2%, and their betas with respect to the S&P 500 are 0.27 and 0.01 respectively. We approximate this in our model by assuming 3% real growth in expenditures with a beta of zero, and 2% real growth in revenues with a beta of 0.3. So for example, under our baseline assumption of a 6% market risk premium, revenues would grow 1.8% per year slower under the risk-neutral measure than under the objective measure.

We use Monte Carlo techniques to calculate the cost of providing defaultable medical benefits for each amortization schedule. The calculations are performed under two investment scenarios: 1.) that the assets set aside to pay benefits are invested in risk-free assets; or 2.) that they are invested in a 70/30 mix of stock-like assets and bonds typical of the asset mix held by state pension plans.

In order to do this we simulate 100,000 possible paths for state revenues and (in the case of investment risk in the medical fund) benefit funding asset returns over the next thirty years at a monthly frequency, under both the objective and risk-neutral measures, assuming that each evolves as a geometric Brownian process. That is, each variable evolves according to

$$X_{t+\Delta t} = X_t \exp\left((\mu_X - \sigma_X^2/2)\Delta t + \sqrt{\Delta t}\sigma_X \chi_{t,X}\right) \tag{4}$$

where $\chi_{t,X}$ is a random draw from a standard normal distribution. The mean growths of the processes under the risk-neutral measure are reduced by the product of the processes' loadings on the stock market and the market price of stock market risk,

$$\mu_X^Q = \mu_X - \beta\lambda, \tag{4}$$

and the processes for state revenues and the returns on risk assets are only correlated through their exposure to the market,

$$\chi_{t,rev} = \rho\chi_{t,assets} + \sqrt{1-\rho^2}\chi_{t,orth} \tag{4}$$

where $\chi_{t,orth}$ is orthogonal to $\chi_{t,assets}$ and $\rho = \beta_{assets,mkt}\sigma_{mkt}/\sigma_{rev}$.

For each path *i* we calculate workers' realized utility on each path using the utility function in equation (3) and assuming that medical benefits are risk free. The expected utility is calculated by averaging over the paths, using the objective probability measure. For each amortization period, we then search to find the required wage premium that delivers the same average path utility when medical benefits can default. Note that the wage premium affects pension benefits through its impact on final-period wages. We perform this calculation under the assumption that in the event of default (i.e., if the revenues to expenditures process ever falls below the critical threshold) medical benefits are paid in proportion to the funding level of the benefits.

Finally, for each amortization period we calculate the cost of total compensation, as well as the cost of providing medical benefits (including wage and pension premia in the cases where medical benefits may default) by calculating the average cost of these over all the paths under the risk-neutral measure.

The employees in the baseline model are risk-averse, so one fact that will drive the results is the demand for smooth consumption. In other words, it is cheaper to provide the risk-averse employees with smooth consumption than variable consumption, other things equal. Another characteristic of this model is that here is a positive market risk premium. Since the employees have no initial market exposure, the optimal funding strategy will give them the optimal amount of market exposure. When the medical fund assets are invested only in risk-free securities, as in the baseline scenario, this market exposure comes from the correlation between government revenues (the stochastic determinant of default) and the stock market. When the medical fund assets are invested in risky securities, this market exposure comes from both the correlation of government with the stock market and the correlation of the medical fund assets (recovery rate) with the stock market.

IV. Results

Figure 5 shows the costs of providing the OPEB benefits for six different horizons to retirement, under our baseline parameter assumptions as shown in Table 4. In the upper left graph, there are only five years to retirement. Here, the PAYG binding non-default, if it were credible, would cost just under $170,000, and the PAYG *until* default with retiree medical benefits going to zero upon default would cost just under $150,000. Note that the PAYG until default cost is inclusive of the wage premium that employees would need to be indifferent between a PAYG binding non-default package and these fully defaultable benefits. For such a short time horizon, it is therefore $20,000 less expensive to pay the risk-averse employees the necessary premiums (that they are presumably earning now) and keep defaultable PAYG benefits. On the one hand, the desire for smooth consumption pushes up the cost of defaultable benefits, but the fact that the default is correlated with the market gives them some market exposure, and thus higher expected benefits, reducing the wage premium they would otherwise charge. For such a short time horizon to retirement, paying down unfunded liabilities will always be more expensive relative to the defaultable PAYG strategy.

As we look at longer and longer periods to retirement, it becomes cheaper to provide the retirement benefits because these benefits will be paid farther in the future and are thus discounted more heavily today. However, the cost of providing the defaultable PAYG does not fall as much as the cost of providing the bindingly non-defaultable benefits. This is because the marginal value of market exposure is falling with the level of exposure, so the first dollar of market exposure obtained through the defaultable benefits is worth the most to participants.[12] As the horizon to retirement gets longer, there is more and more exposure. At 20 years to retirement, the costs of PAYG binding non-default and defaultable PAYG are about the same at around $121,000. At 30 years, the PAYG binding non-default costs around $98,500 and the defaultable PAYG strategy costs just over $102,000.

The red lines in the figures show that for horizons of longer than around 5 years, there is a strategy of amortizing unfunded liabilities over a certain number of years that reduces the costs of providing the benefits, net of the wage premia that are paid. Recall that at every point in the graph, employees are indifferent between a bindingly non-defaultable benefit and the given strategy — the paydown of liabilities over $\underline{t}$ periods, where t is the value on the x axis, with default entailing a recovery of any assets in the medical fund. In the limit, a paydown period of an infinite number of years is equivalent to defaultable PAYG funding.

For a horizon of 10 years to retirement, this cost-minimizing funding strategy targets fully funded benefits at 20 years, and for the longer horizons at around 18 years. These strategies are the least expensive to provide employees because it optimizes their joint desire for smooth consumption and some amount of market exposure. Very short paydown periods, say of one or two years, are very costly because default is essentially certain. The medical fund contributions affect expenditures and make it very likely that the expenditures will rise by much more than

[12] As will be seen later, when there is no market risk premium, the spread between the PAYG binding non-default and the risky strategy remains constant as the horizon of years to retirement gets longer.

revenues. Risk-averse employees therefore require a premium that makes such a strategy cost more than binding non-default.[13] As the paydown period gets longer from these very short paydown periods, the consumption smoothing properties become more desirable, and also the employee receives market exposure. After a certain number of years, the paydown period line turns up and asymptotes the market exposure. For the longer horizons, either the market exposure is too great, or the amount consumption smoothing too small, or both, as we shall see momentarily.

Figure 6 shows the 20-year to retirement scenario with different levels of risk aversion: 0, 1, 2, and 5, where 1 is the same as the baseline. Note that the cost of the binding non-defaultable PAYG benefits is the same regardless of employee risk aversion, since this is the baseline to which the employees are made indifferent in each case. The first graph shows that if employees are risk-neutral (risk-aversion of zero), it is much less expensive to provide them with defaultable PAYG benefits than if they are risk-averse. Furthermore, it is also less expensive to pay down unfunded liabilities over a given number of years. The upper left corner risk-neutral case is also instructive because it highlights that even if the government takes a strategy that is certain to lead to default, risk-neutral employees can be compensated in expected value in such a way as to make them indifferent to PAYG binding non-default at the same cost.

Furthermore, the shape of the line that shows the costs of funding over each amortization period is essentially the same in the risk-neutral case as in the risk-averse case. This shows that even in the absence of a desire for smooth consumption, there is still an optimal amortization period of around 18-20 years due to the ability to give employees an optimal amount of market exposure.

As the risk-premium increases, the costs of the PAYG until default strategy become more expensive, and with them the risky pre-funding strategies over a specific period of years. With a risk-aversion parameter of 2, there is still a cost justification to pre-fund using an amortization period of around 18 years even relative to binding non-default (which may not be possible). At a risk-aversion of 5, it would be cheaper to be able to commit to non-default but if the employer cannot do that then pre-funding over the optimal amortization period is nonetheless cheaper than PAYG until default.

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[13] As will be seen later, when employees are risk-neutral they are indifferent between this strategy and binding non-default.

Figure 7 shows the results for the log-utility employee when there is no market risk premium. Interestingly, while this case makes defaultable PAYG more expensive than binding non-default in all cases, paying down liabilities over the optimal period of years (here closer to 15) is still cheaper than just continuing PAYG until default. This is because of the effects of consumption smoothing. Very short amortization periods will increase the likelihood of the default barrier being breached, and hence might provide less smooth consumption, but amortizing over too long a period lowers the recovery rate in default. So even on consumption smoothing grounds alone, there is an interior solution for the optimal amortization period.

Figure 8 shows these calculations assuming a low market risk premium of 2% per year. Note that relative to Figure 7, the cost of providing a PAYG benefit until default is lower for each horizon than with zero market risk premium, as the employees gain the benefit of market exposure through the correlation between the default event and the market. The graphs show that for horizons to retirement of 10 years or more, even with this low risk-premium it can be cheaper to provide defaultable benefits with a 20-year paydown period than to give a credible commitment of non-defaultable benefits. Again, all of these cost calculations consider the wage premium that would need to be provided to make the employee indifferent between the defaultable benefit under the given paydown period and the credible commitment of a non-defaultable benefit.

Figure 9 shows the sensitivity of the results to changing the default boundary (on the ratio of own-revenues to expenditures) to values less than 0.50. The left three graphs are with a market risk premium of zero and the right three graphs are with a market risk premium of 0.6. Comparing the right-side graphs to Figure 5, the cost of providing benefits 20 years to retirement using defaultable PAYG declines as the default threshold gets lower, since the compensation required by employees is not as large. This is similarly the case when the market risk premium is zero, as shown in the left column. When default thresholds are sufficiently low and there is no market risk premium, it becomes optimal to fund the plan quickly as employees do not benefit at all from market exposure through the government revenue process. Adding the market risk premium at the low default boundaries introduces a nonmonotonicity in the cost of funding over increasing amortization periods. There is a small range (from around 2 to 5 years) over which workers are exposed to less market risk than if they amortize faster (bringing them closer to the default boundary initially) or over longer periods (over which the market risk compounds). This nonmonotonicity is completely a function of the optimal market exposure with positive risk premiums, not related to consumption smoothing, and is present even for risk-neutral agents (not shown) as long as there is a positive risk premium, but is not manifest when risk premium is zero.

Figure 10 shows the baseline but with investment risk in the medical fund assets. The positions of the PAYG binding non default line and the PAYG until default lines are naturally the same as in Figure 5 as these analyses are unaffected. The minimum point on the line that shows prefunding over the various amortization periods is lower than without investment risk in the medical fund, as the arrangement provides employees with more market exposure.

V. Conclusion

If RHI liabilities are to be paid in full then their economic magnitude is understated by government accounting. If in contrast these are defaultable benefits, then their market value may be substantially lower, crediting the government for its option to default. The market value of these defaultable benefits will therefore be substantially lower than their face value, a function of the fact that these are liabilities junior to more senior debt (pensions) that are underwater. Moving beyond valuation, we have considered optimal funding strategies in a model where public employees are risk averse and have no market exposure outside of their benefits. We have shown that interior funding solutions emerge when individuals are risk-averse or when there is a positive market risk premium with default triggered in part by priced risks. This analysis assumes that the labor markets that determine public employee pay work sufficiently well to generate compensating differentials for the prospect of reduced benefits.

We close with several important directions for future work. First, there can be tax advantages to pre-funding. If a prefunding structure qualifies under IRS rules, beneficiaries may be able to make their own contributions to premiums in a tax-efficient manner. Second, we have not modeled the possibility that even including the cost of implicit subsidy, the provision of RHI might have additional value to the retiree due to the high cost of health insurance in the private market. Third, we have not modeled the possibility of federal bailouts. If the federal government might backstop retiree health benefits, then they are considerably less risky to employees than we have assumed. In Chicago, for example, a 2013 panel issued a report that raised the possibility of sending pre-Medicare retirees onto the state's Affordable Care Act ("ObamaCare") exchange in 2014, presumably with some subsidy.[14] So this would be giving the retirees money to buy private insurance. Finally, we have assumed that medical benefit costs are deterministic, taking the government medical cost inflation forecasts as given. Considering the distribution of possible outcomes for medical cost inflation and its impact on public medical programs is an important avenue for future research.

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[14] See "Rahm's ObamaCare Brainstorm," Wall Street Journal, 25 January 2013.

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Figure 1: Pension Contribution Behavior in Reform and Non-Reform Cities

The graphs show the actuarially required contributions (ARCs) and actual city contributions to city pension plans in two reform and one non-reform city. Teachers plans are excluded. San Jose includes the Federate City and Police and Fire plans. San Diego includes the City, Port, and Airport plans. Chicago includes the Police, Fire, Municipal, and Laborers Plans. Data are from the city and pension system comprehensive annual financial reports.

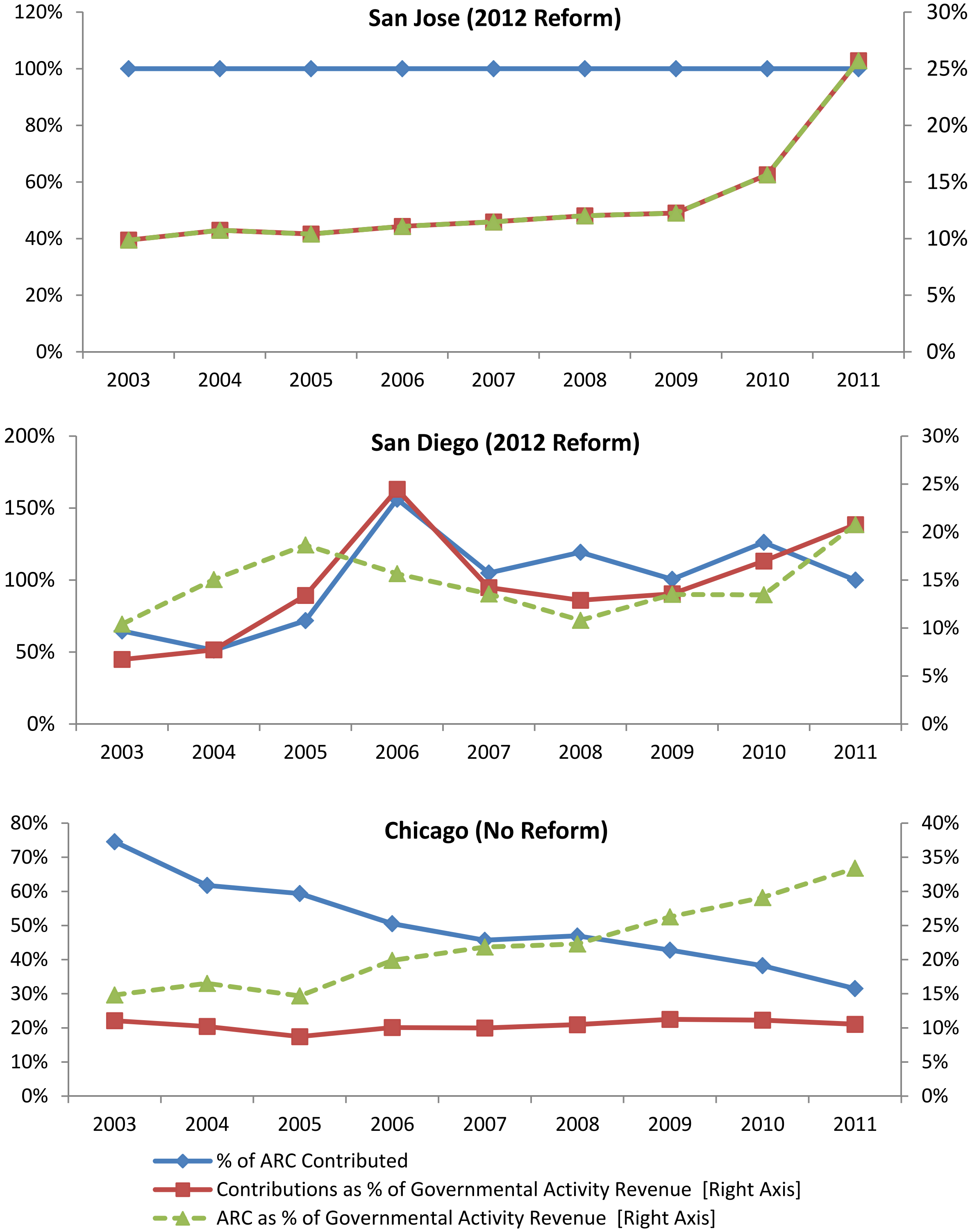

Figure 2: Expected OPEB Cash Flows for California State Employees

This figure shows the projected annual costs of providing post-retirement medical benefits to state-employee members of CalPERS who in 2011 numbered 150,973 retirees and 257,175 active employees.

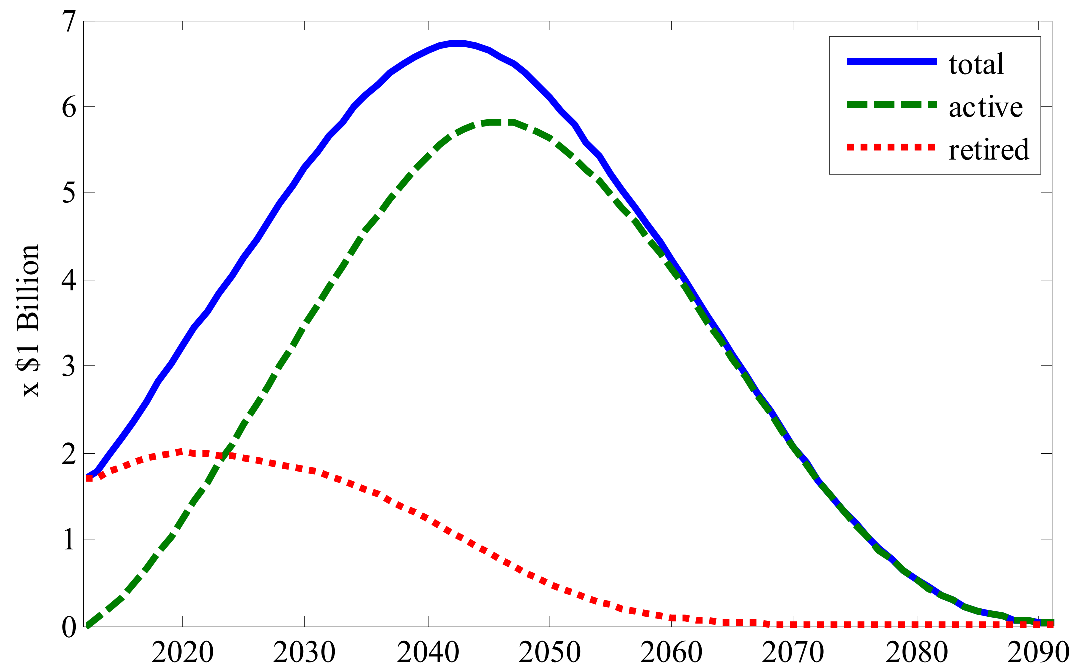

Figure 3: Zero-Coupon Yield Curves as of December 2012

[Explanatory note here]

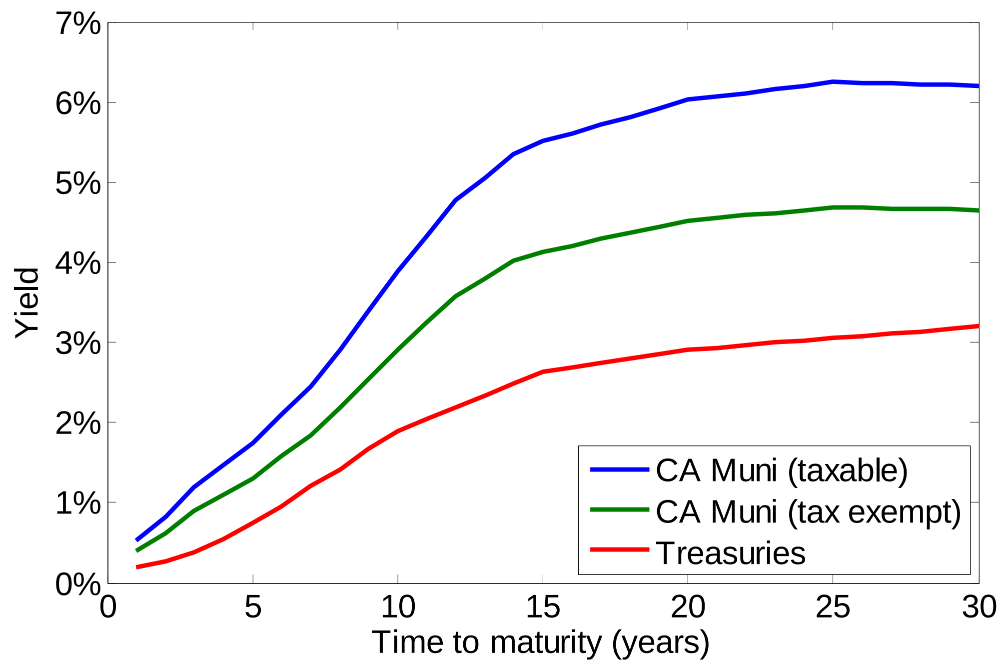

Figure 4: California State Historical Revenues (Excluding Federal Sources) and Expenditures

The figure shows the historical levels of state revenues, state expenditures, and the Fama-French excess return index. State government data are from the California Legislative Analyst's Office website and the Fama-French excess returns are from the website of Kenneth R. French.

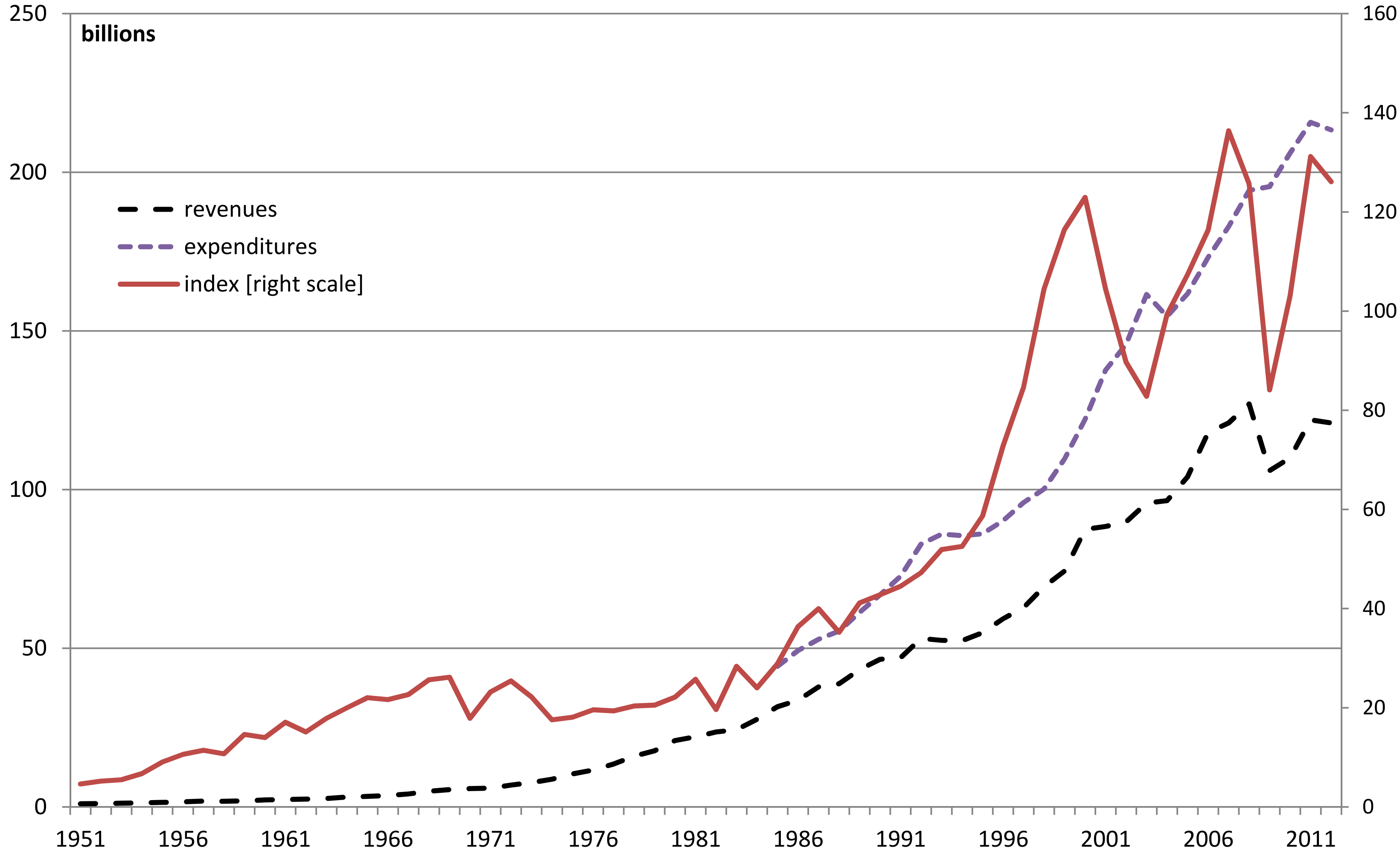

Figure 5: Optimal Funding Strategy, Baseline Specification

The figure shows the costs of providing RHI benefits in the model with compensating wage differentials that would make employees indifferent between the given funding strategy and PAYG binding non-default for the parameters shown in Table 4. The medical fund assets are assumed to be invested in the risk-free asset.

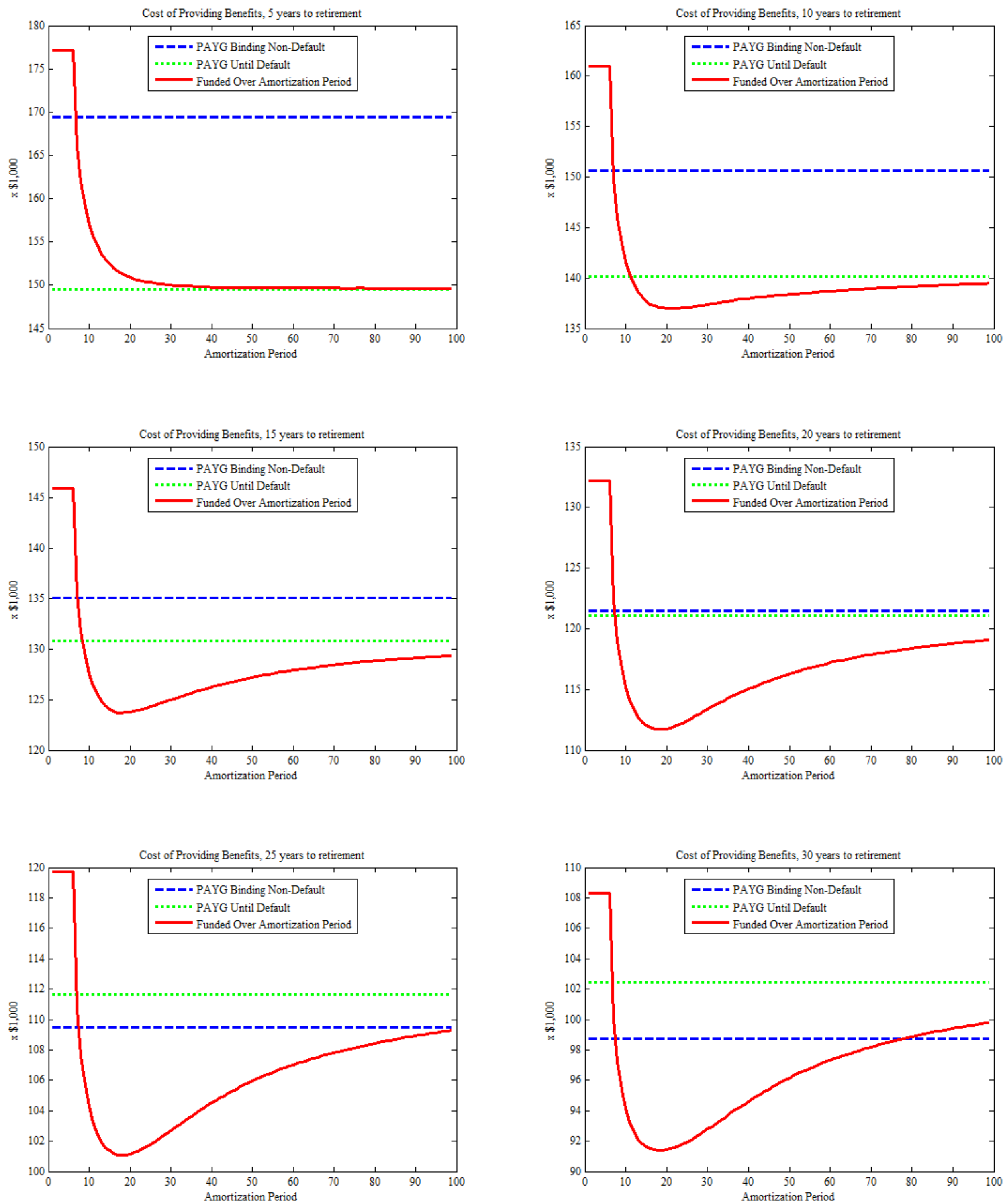

Figure 6: Optimal Funding Strategy 20 Years to Retirement Under Various Risk Aversions

The graphs show the costs of providing RHI benefits under the baseline parameters from Table 4 with different risk-aversion coefficients

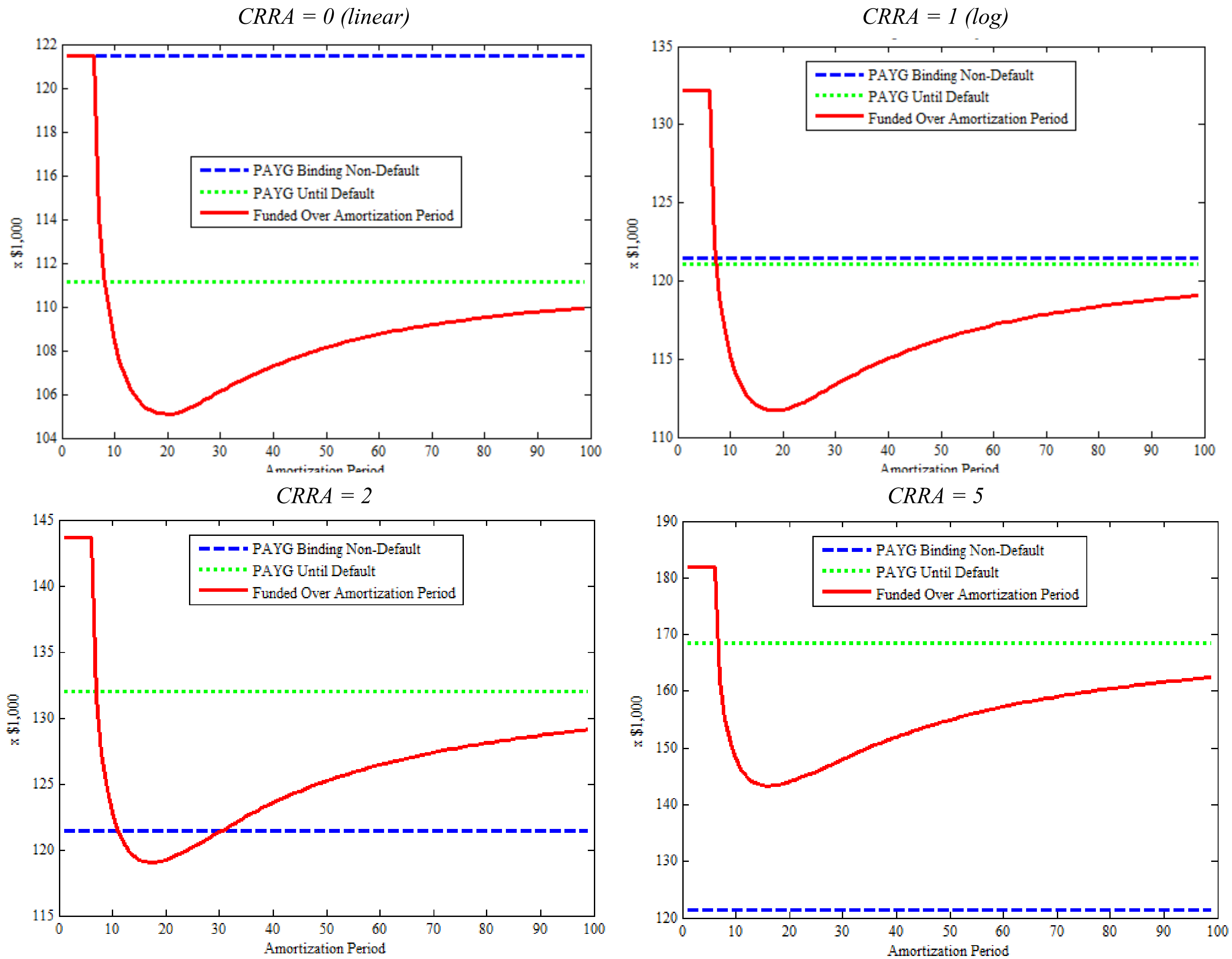

Figure 7: Baseline Scenario but No Market Risk Premium

The figure shows the costs of providing RHI benefits in the model with compensating wage differentials that would make employees indifferent between the given funding strategy and PAYG binding non-default for the parameters shown in Table 4, but with the market risk premium set to zero instead of 6%.

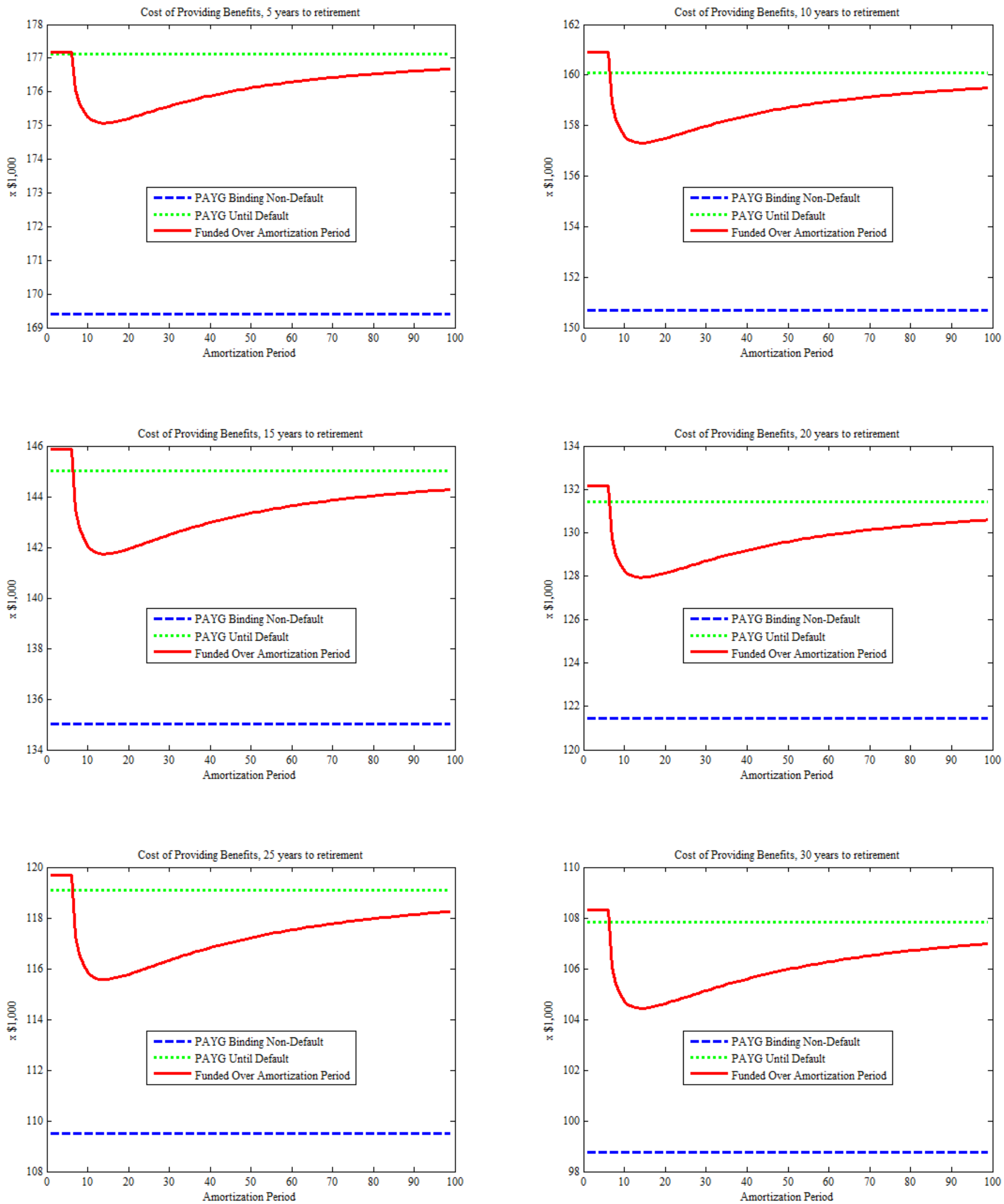

Figure 8: Baseline Scenario, Low Market Risk Premium

The figure shows the costs of providing RHI benefits in the model with compensating wage differentials that would make employees indifferent between the given funding strategy and PAYG binding non-default for the parameters shown in Table 4, but with the market risk premium set to 2% instead of 6%.

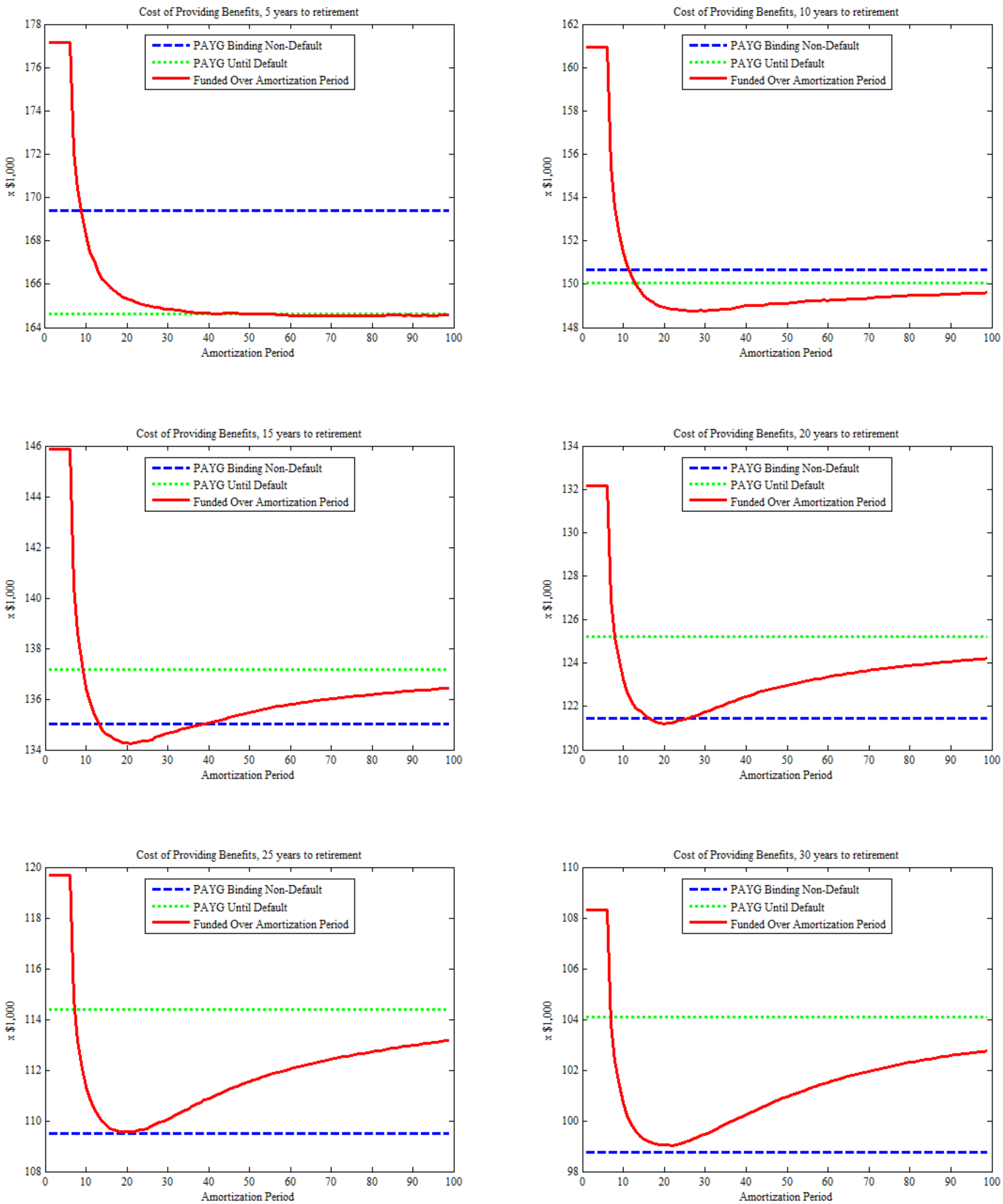

Figure 9: Optimal Funding Strategy 20 Years to Retirement, Various Default Boundaries

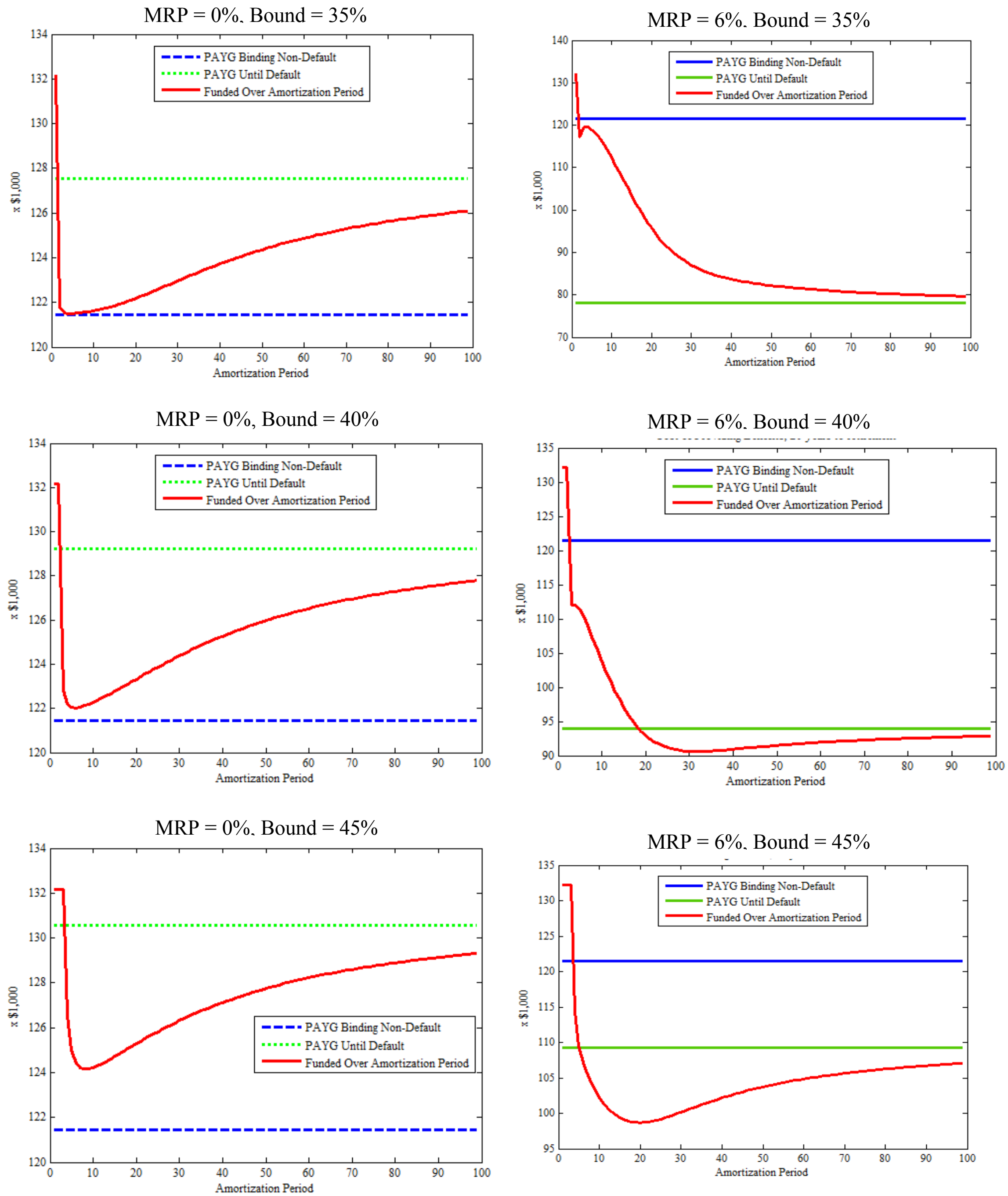

Figure 10: Baseline Scenario With Investment Risk in Medical Fund Assets

The figure shows the costs of providing RHI benefits in the model with compensating wage differentials that would make employees indifferent between the given funding strategy and PAYG binding non-default for the parameters shown in Table 4, with medical fund assets having a market beta of 0.7.

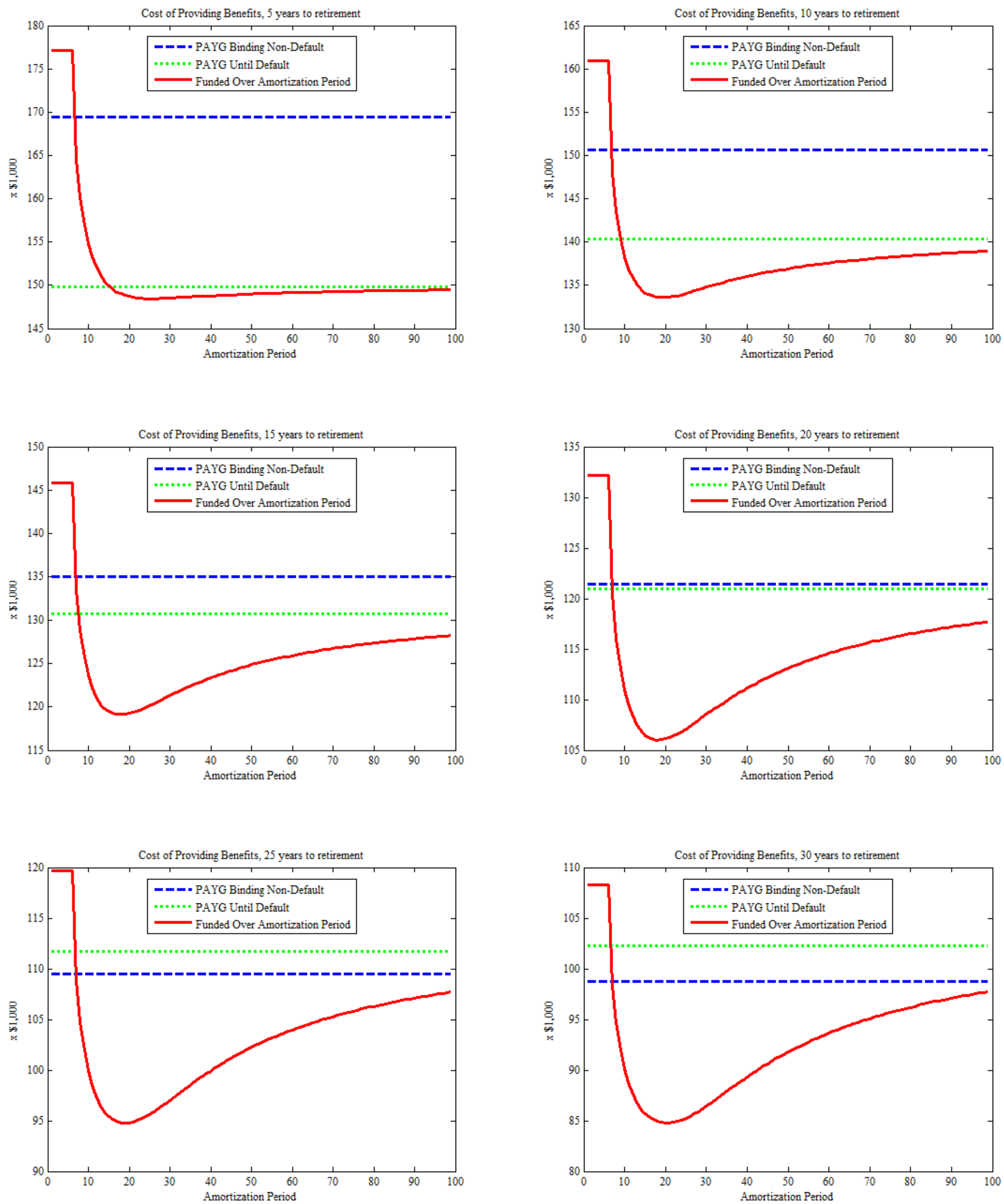

Table 1: Governmental Accounting for California State Retiree Health Liabilities

This table shows figures collected from state government disclosures on the present value of liabilities, the accrual costs, and the expected actual employer contributions under three different funding strategies which under GASB 45 imply three different discount rates. The tabulation includes all non-school members of state retiree health plans other than legislators and judges, a total of 150,973 retirees and 257,175 employees. University of California employees are also excluded. Source: CalPERS (2011). PV of Liabilities (Accrued) is the present value of the benefit cash flows attributed only to employee service earned in prior fiscal years. PV of Liabilities (Total) is the present of the expected cash flows for current employees and retirees. The Annual OPEB Cost is the accrual cost of new benefit promises. Net OPEB Obligation is the cumulative difference between the Annual OPEB Cost accruals and the actual employer contributions. It is analogous to an unfunded PV of Liabilities (Accrued) but only cumulated from when the state began accrual accounting in 2007.

	Funding Strategy and Discount Rate		
	Full	Partial	PAYG
Item ($ billions, 2011)	7.610%	6.055%	4.500%
PV of Liabilities (Accrued)	$40.4	$49.3	$61.6
PV of Liabilities (Total)	$49.8	$64.6	$87.1
Net OPEB Obligation	$10.0	$11.3	$12.8
Annual OPEB Cost	$3.5	$3.9	$4.7
Expected Employer Contribution	$3.3	$2.5	$1.7

Table 2: Fragmentation of Government Employee OPEB Plans in California

This table shows the largest state and local government OPEB plans in California. The California Public Employee Post-Employment Benefits Commission (2007) cited 198 cities, 53 counties, 188 special districts, and 39 community college districts that sponsor these plans. The first row represents the plans covered in Table 1.

	Recipients	Active Employees	Contributions, % of Revenues	Accruals, % of Revenues
State				
State Employees (‘11)	150,973	257,175	1.8%	2.3%
University of California (‘11)	36,234	113,898	1.4%	2.3%
Local				
County of LA (’10 / ‘11)	41,786	94,343	2.5%	11.8%
LA Unified Schools (’12)	NA	72,000+	3.0%	13.9%
City of Los Angeles (LA) (‘11)	13,436	25,449	*8.8%*	*8.1%*
San Francisco (’09 / ‘11)	16,269	28,298	2.0%	5.5%

Table 3: Total Liabilities of Retiree Health Insurance Plans for California State Employees

The table shows the California state employee RHI liabilities discounted at different yield curves. The top panel shows the discounting at the three flat rates presented in CalPERS (2011). The bottom panel shows our estimates of the underlying cash flows (which are shown in Figure 2) discounted at the yield curves shown in Figure 3.

$ billions	Retired	Active	Total
State's Calculations			
7.610%	22.0	27.8	49.8
6.055%	25.8	38.8	64.6
4.500%	30.9	56.2	87.1
Our Calculations			
CA Tax Exempt Muni	33.6	54.0	87.6
CA Taxable Muni	29.0	37.2	66.2
Treasury Curve	40.2	81.3	121.6

Table 4: Table of Baseline Assumptions in the Model

This table shows the baseline assumptions in the model. All discount rates and growth rates are in real terms. In the baseline scenario we assume that the medical funds are invested in risky assets. β_A is the parameter in the scenario with investment risk only. In Figure 8 we show runs with $\beta_A = 0.7$.

Parameter	Baseline	Description
Γ	1	Relative risk aversion
MRP	0.06	Market risk premium
R	0.02	Risk-free rate
g(exp)	0.03	Mean growth of expenditures
g(rev)	0.02	Mean growth of revenues
W	50	Wages
M	12	Medical benefits
HP	20	Home production
σ_{rev}	0.065	Volatility of revenues
β_{rev}	0. 3	Loading of revenues on market
β_A	0 (or 0.7)	Fund asset beta (if investment risk)
$[Rev/Exp]_0$	0.57	Starting revenue to expenditure ratio
$[Rev/Exp]^*$	0.50	Default threshold