PRELIMINARY

The Design and Cost of Pension Guarantees

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Abstract

Conversions from defined-benefit (DB) pension systems to individual defined-contribution (DC) accounts often create new unfunded liabilities in the form of minimum benefit guarantees. Several approaches have been advocated in the past to reduce the value of these guarantees. The least restrictive approach would simply require agent's to "over save" in their DC accounts so that the expected benefit at retirement is significantly larger than the minimum benefit. A more restrictive approach would also only guarantee a "standardized" portfolio, requiring agents to accept any "basis risk" if they chose a non-standard portfolio. An even more restrictive approach would require agents to prefund some of the guarantee level, maybe by agreeing to sell off part of the potential "upside" of the returns in exchange for insurance against the downside.

This paper shows that the minimally-intrusive over-saving approach is not a very effective device at reducing the unfunded liability associated with the guarantee. While the *probability* of avoiding a shortfall can decrease significantly in the saving rate, the *risk-adjusted value* of the guarantee decreases very slowly since protection against "very low" returns is much more valuable than protection against "just low" returns. Providing insurance only for a standardized portfolio, though, is much more effective at reducing unfunded liabilities. But to the extent that the standardized portfolio itself includes risky assets and relies on their returns to provide the minimum benefit, the unfunded liability can be fully eliminated only by prefunding the guarantee. Of course, the guarantee does not need to be prefunded to eliminate liabilities if the standardized portfolio includes risk-less assets and the contribution rate is set high enough so that these risk-less assets alone can generate a retirement benefit at least equal to the guaranteed benefit amount. It appears that this latter approach is essentially being taken by US presidential candidate G.W. Bush in his plan to convert a portion of the US Social Security system to private accounts.

I. Introduction

Many plans to convert the mostly unfunded US Social Security defined-benefit program to individual-managed accounts contain liabilities in the form of unfunded minimum benefit guarantees. A recent proposal by Senator Phil Gramm (1998), for example, would guarantee that a worker receives an annuitized benefit equal to 100 percent of what they would have received under Social Security plus 20 percent of the value of the investment they build up "over their working lives." In Smetters (1999), I show that the unfunded liability associated with this minimum benefit guarantee could actually be larger than Social Security's existing unfunded liability. Full conversion to "funded" private accounts could actually lead to an increase in unfunded liabilities.

In Smetters (1999), my analysis followed the conversion design outlined in Feldstein and Samwick (1997) who popularized the startlingly idea that a private account, with a contribution rate equal to only two percent of payroll, could be used to eventually replace the much larger Social Security payroll tax while producing the same *expected* benefit. Private saving in the new accounts were assumed to be fully invested in market capital that produced a (social) annual real rate of return equal to nine percent, which is also the mean historical return to the S&P500. Compound interest rules the day: over a thirty year saving horizon, private account assets eventually become as valuable as the average Social Security benefit which, by the year 2075, must be financed with a payroll tax rate that is close to 10 times larger than the contribution rate in the two-percent private accounts.[1]

My analysis considered the impact on unfunded liabilities of adding a minimum benefit guarantee to the Feldstein-Samwick type of equity-based accounts. Whereas unfunded liabilities are eliminated in the Feldstein-Samwick experiment if there is no guarantee (since private agents would

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[1] See Table II.F13 of the 2000 Social Security Trustees Report.

bear the risk), my analysis showed that unfunded liabilities were reduced only by about 13 percent if the government actually *guaranteed* that the new accounts would replace the Social Security benefit that people would have received. This small change in liabilities reflects the expensiveness of the guarantee when the contribution rate in the private accounts is only two-percent.

The current paper considers three strategies to reduce the expensiveness of a benefit guarantee, starting from the least restrictive approach. The first strategy increases the contribution rate so that the expected benefit in the new mandatory private account exceeds the guaranteed minimum benefit level by some proportion.[2] The second strategy guarantees only a "standardized" portfolio rather than the exact portfolio chosen each agent; investors, therefore, bear the "basis risk" to the extent that they choose a portfolio different than the standard. The third strategy requires inter-generational transfers to future generations as a way of prefunding the guarantee.

Assuming that the new mandatory private accounts are fully invested in risky equities is an interesting place to start the analysis herein. As proven below, no matter how small the benefit guarantee, rational investors facing no market participation constraints would invest 100 percent of the assets contained in their new mandatory private accounts into equities. This investment strategy maximizes the value of the benefit guarantee without altering the investor's desired shares of *total* wealth – including non-mandatory saving – devoted to equities or bonds (i.e., no change in the Sharp ratio). In particular, assuming identical tax treatments of the mandatory and non-mandatory saving accounts, rational investors would reduce their stock holdings in their non-mandatory accounts (possibly going negative) and increase their positive equity position in their mandatory account to 100 percent. Presumably, obvious investment restrictions governing the mandatory account would

[2] This option was also examined in Smetters (1999). The current paper examines it more thoroughly.

prevent additional leveraging (i.e., effectively going over 100 percent in equities).

The first strategy attempts to "oversave" as way to reduce the value of the benefit guarantee, but it is not very successful at reducing guarantee risk. To be sure, a higher contribution rate reduces the rate of return to equities that is necessary to produce a retirement benefit in excess of the minimum. But even with a large contribution rate of 10 percent of payroll – which requires almost doubling the payroll tax in the short run to meet preexisting liabilities – a guarantee to replace the Social Security benefit level reduces unfunded liabilities only by about 30 percent. This is true even though the expected retirement benefit after conversion is now five times larger than the Social Security benefit, and so the probability of falling below this benefit level is very small.

Intuitively, the value of the unfunded liabilities decreases very slowly in the contribution rate since protection against "very low" returns is much more valuable than protection against "just low" returns in the presence of a large equity premium reflecting risk. This result highlights the importance of measuring the *risk-adjusted* cost of a guarantee, as incorporated by existing market prices[3], instead of focusing on the *probability* of a market downturn.

To deal with this guarantee-induced moral hazard problem, the second strategy analyzed herein considers a guarantee over a "standardized" portfolio mixed with bonds. Under this approach, the government does not insure the exact portfolio chosen by investors. Instead, the government insures a standardized portfolio consisting of a certain mix of stocks and bonds. Investors are fully protected up to the specified guarantee level if they choose the standardized portfolio mix. But investors bear the "basis risk" for any deviation they choose from the standardized portfolio.

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[3] As discussed in Smetters (2000*a*), this assumption assumes complete Arrow-Debreu markets. As shown in Smetters (2000*b*), this assumption might be fairly plausible at the current capital income tax rate and with about a three-quarters correlation between wages and capital income returns at a low generational frequency. Empirically, the point estimate correlation is about three quarters but the standard error is quite large.

Insuring only a standardized portfolio has some precedence. The public employee pension system in the State of Florida has just initiated the largest public conversion in history from a defined-benefit system to a defined-contribution system. In that system, Florida public employees can, upon reaching retirement, buy their way back into the public system by paying back their contributions grossed up by the rate of return earned by the *public* system over the time period that the employee was out of the public system (see LaChance, Mitchell, and Smetters, in progress). Insuring a standardized portfolio, instead of indemnifying individual losses, is also the approach taken in modern catastrophic hedging contracts as a way of reducing an inefficiently low investment is loss control which is generated by moral hazard (Doherty and Smetters, 2000).

While insuring only a standardized portfolio decreases the guarantee risk placed on future generations, this policy reform alone generally does not eliminate all the risk. The reason is that standardized portfolio itself will typically be risky and that risk may be borne by future generations.

One important exception would be if the standardized portfolio consists of enough risk-free bonds which, themselves, are able to produce a retirement benefit at least equal in size to the guaranteed benefit. In this case, the guarantee risk to future generations would be zero. My analysis below suggests that this approach (I believe) is essentially being taken by US presidential candidate G.W. Bush in his plan to convert some of US Social Security system to private accounts.

Of course, under a different or a modified plan, returns in excess of the risk-free rate could someday be relied upon to pay for future obligations. The political nicety of attempting to rely on returns in excess of the risk-free rate is that this approach would reduce the amount of the budget surplus that must be used today to pay for conversion. The risk passed to future generations could then be non-trivial. The cost of this risk could only be reduced with inter-generational transfers from current workers to *future* generations to pay for the benefit guarantee.

One way to transfer resources forward in time to help pay for a minimum benefit guarantee would be to *prefund* Social Security's existing defined-benefit structure – that is, without carving out private accounts. Since the Social Security benefit remains fixed under this approach, prefunding exposes future generations to both the "downside" risk of the benefit guarantee as well as the "upside" potential of higher equity returns. As shown in Smetters (1998), current generations, in effect, write future generations a call stock option over a broad equity mix (giving future generations the upside potential) in exchange for future generations writing the current generation a put option (requiring future generations to bear the downside risk). The call option implicitly *helps* to pay for the put option.[4] As a result, prefunding the existing benefit level reduces unfunded liabilities more than a privatized system that guarantees the existing benefit level, as privatization extracts a put option from future generations but does not give them the call option in return.

However, prefunding has its own risks and, in practice, may be more risky than privatization. The reason is that, relative to mandatory private accounts, the prefunding approach suffers from a lack of transparency which might lead to higher *scoring-based risk* as well as higher *storage risk*.

In terms of scoring-based risk, a prefunded system would likely be scored under traditional procedures which focuses on *expected* returns. For example, for President Clinton's recent proposal to invest part of the Social Security trust fund in equities was scored by the CBO and OMB by focusing on expected returns despite the obvious prediction of a free lunch (Bazelon and Smetters, 1999; Smetters, 2000*a*). There is no reason to believe that this scoring approach will be changed in

[4] This approach has also been taken more recently in an interesting paper by Feldstein and Rangelova (2000). But they consider a decentralized approach in which living generations trade among themselves. Since their trades are voluntary, the guarantee risk across generations cannot be fully eliminated unless, like the Bush plan, the system is already designed to produce a replacement benefit that does not rely on equity returns in excess of the risk-free rate.

the future.[5] As a result, a "fully" funded system under traditional scoring rules would be only partially funded in a risk-adjusted sense. Equivalently, the call option transferred to future generations, as mentioned above, could be worth only a small fraction of the put option extracted from future generations (see calculations below).

Risk allocation in a defined-benefit system is not very transparent which plays a key role in creating scoring-based risk. Since retirement benefits remain defined by law, individual pensioners would not directly observe the risks imposed upon future generations as the result of a scoring process that focuses on expected returns. In contrast, transparency would be higher with private defined-contribution accounts; in particular, too much reliance on high expected equity returns would probably generate the need for a higher contribution rate or an explicit minimum benefit guarantee. To the extent that higher contributions are used, as appears to be the case in the Bush plan, future taxpayers could be exposed to less risk with private accounts than with prefunding.

In terms of storage risk, prefunding relies heavily on the government being able to store or "lock box" assets to pay for future benefits. A true "lock box," however, has eluded policymakers since the inception of Social Security (Schieber and Shoven, 1999). The Social Security trust fund, for example, was taken "off budget" during the 1980s. That budgetary change was suppose to lead to greater transparency of the greater store of value represented by the trust fund. But policymakers, along with the CBO and OMB, continued to set spending targets based on the *unified* budget measure that includes trust fund income. Barry Bosworth (1996, p. 104) questions whether it is legitimate to assume that these other policy variables remain constant when actions are taken to boost trust fund reserves. In his view, those actions could eventually be offset by changes elsewhere

[5] I.e., it is hard to imagine a public outcry for risk-adjusted scoring

in the budget. "Most Americans," he argues, "are normally very surprised to learn that the surplus is being used to finance other programs, and that in most public discussions the budget deficit is defined to include the finances of social security." Indeed, the retiring Senator Daniel Monyihan has often argued that the decision to begin building up the trust fund during the 1980s was nothing more than a clever Republican regressive tax reform to create higher labor taxes, levied over a limited wage tax base, in order to pay for lower income taxes, levied over a more progressive tax base that includes capital income. If Monyihan is right, then the growth in the Social Security trust fund during the past two decades has failed to significantly increase public and national savings to pay for future benefits.

There is no real reason to believe that a larger trust fund – or one invested in equities – would generate a more secure lock box since net income to trust fund would still be included in the unified measure of the budget surplus. While prefunding advocates often talk about a "true lock box," their ideas really only amount to an agreement that the CBO and OMB will no longer include trust fund net income in a unified surplus measure, or that policymakers will *now* focus on the "on budget" surplus, maybe with trust fund assets held in separate capital account. But these types of agreements are not really novel and, in any case, they are easy to undo, especially in times of "great need." The reason is that the incidence of imperfect storage would likely fall on future generations, and would, in all likelihood, escape the attention of current taxpayers and pensioners who would continue to pay the same taxes and receive the same defined benefits. Trust fund assets can also be leveraged by using "pension-backed obligation bonds," like those issued recently by many states to leverage their public employee pension assets. In contrast, spending assets held in private accounts would have to be much more explicit; confiscating those assets would be a noticeable undertaking.

II. A Minimum Benefit Guarantee

Lifecycle agents live for two periods and their expected lifetime utility equals,

$$E_t\left\{\sum_{j=1}^{2}\lambda^j U\left(c_{j,t+j-1}\right)\right\} \tag{1}$$

where $c_{j,t}$ is the consumption at age j in year t and 8 is the discount factor.

The generation-t agent earns wage income equal to w_t revealed at beginning of year t, consumes $c_{1,t}$ at age 1 and saves the difference, s_t . A share of their savings, α_t , is invested into a risk-free bond that pays r_{t+1} in year t+1. The other $\left(1-\alpha_t\right)$ share of saving is invested into equities paying a risky rate of return equal to e_{t+1} in year t+1. The individual faces a Social Security payroll tax equal to J^S, the proceeds of which are invested into a pay-as-you-go Social Security asset that pays a net internal rate of return equal to $g_{t+1} \equiv \left(\frac{w_{t+1}}{w_t}\right)-1$. The individual's budget constraints during the first and second period of life are:

$$s_t = \left(1-\tau^S\right)w_t - c_{1,t} \tag{2}$$

$$c_{2,t+1} = s_t \cdot \left[\left(1+r_{t+1}\right)\alpha_t + \left(1+e_{t+1}\right)\left(1-\alpha_t\right)\right] + \tau^S w_t\left(1+g_{t+1}\right) \tag{3}$$

The agent chooses the level of saving, s, and the portfolio share, ", to maximize equation (1) subject to the constraints (2) and (3). The first-order conditions are:

$$U'\left(c_{1,t}\right) = \lambda\left(1+r_{t+1}\right)E_t\left[U'\left(c_{2,t+1}\right)\right] \tag{4}$$

$$U'\left(c_{1,t}\right) = \lambda \cdot E_t\left[\left(1+e_{t+1}\right)\cdot U'\left(c_{2,t+1}\right)\right] \tag{5}$$

The economy's production technology is not explicitly modeled. Instead, it is simply assumed that the stock process can be described by an Itô-type stochastic differential equation and, without loss in generality, has a stationary expected yield $\overline{e} \equiv E_t\left(e_{t+1}\right)$. While $r = \overline{e}$ for linear utility, the inequality $\overline{e} > r_{t+1}$ holds in the presence of risk averse preferences (i.e., $U' > 0$, $U'' <$

0). Hence, it is not correct to compare only the *expected* payoffs of bonds versus stocks.

<u>A Stylized Conversion Proposal</u>

Conversion to private accounts begins with generation 1, the current workers. Generation-0 agents, the current elderly, receive benefits under the current pay-as-you-go Social Security system. These benefits are paid for by generation 1 – the "transitional generation" – who, in turn, receives nothing from Social Security. Instead, the generation-1 agent faces a new mandatory payroll tax, τ^M, on top of their existing Social Security payroll tax which is invested into a private account as a way of replacing the lost Social Security benefit.[6] Generation 2, and all subsequent generations, no longer face the Social Security tax rate but instead contribute only $\tau^M \cdot w_t$ to their new mandatory private account. Let β_t denote the fraction of the new mandatory private account which is invest in the risk-less asset, while $1-\beta_t$ represents the fraction invested in equities.

The government guarantees that the new mandatory private account for each generation *t* ($t \geq 1$) will replace at least some fraction, χ, of the benefit that generation *t* would have received under Social Security, i.e., $\chi \cdot \tau^S w_t\left(1+g_{t+1}\right)$. A value of $\chi = 1$ means that the new account yields a benefit at least equal to benefit that an agent would have receive under Social Security. This guarantee is paid for using a state-contingent tax on the wage income of generation *t*+1:

$$\text{(6)} \qquad \tau_{t+1}^c = \frac{\max\left\{0, \chi \cdot \tau_t^S w_t \cdot \left(1+g_{t+1}\right) - \tau^M w_t \cdot \left[\left(1+r_{t+1}\right) \cdot \beta_t + \left(1+e_{t+1}\right) \cdot \left(1-\beta_t\right)\right]\right\}}{w_{t+1}}$$

The budget constraints for generation *t* ($t \geq 1$) are now

[6] This new tax is "almost equivalent" to using budget surplus to pay for either new private accounts, or using budget surpluses to pay for existing liabilities in order to allow for a portion of the Social Security tax to be diverted to private accounts. The equivalence would be exact if the general revenue tax base was the same as Social Security.

(2') $$s_t = \left(1 - \tau^S - \tau^M\right) w_t - c_{1,t}$$

(3') $$\begin{aligned} c_{2,t+1} = s_t \cdot \left[\left(1 + r_{t+1}\right)\alpha_t + \left(1 + e_{t+1}\right)\left(1 - \alpha_t\right)\right] + \\ \tau^M w_t \cdot \left[\left(1 + r_{t+1}\right)\beta_t + \left(1 + e_{t+1}\right)\left(1 - \beta_t\right)\right] + \tau^c_{t+1} w_{t+1} \end{aligned}$$

where $\tau^c_{t=1} = 0$. Now generation *t* chooses S_t, α_t, and β_t to maximize equation (1) subject to constraints (2') and (3'). Denote the optimal values of these variables with asterisks (*).

Proposition 1. $\beta^*_t = 0$. I.e., all assets in the new mandatory account are invested in equities.

A sketch of a proof is as follows. Define $M_t \equiv \lambda u'\left(c_{2,t+1}\right) / u'\left(c_{1,t}\right)$. By contradiction, suppose that $\beta^*_t > 0$. Then the agent could increase α^*_t by $\beta^*_t \tau^M w_t / s^*_t$ and decrease β_t to zero. The sum of the first two terms on the right-hand side of equation (3') does not change, but the utility value of the contingent tax payment received from generation *t*+1, $E_t\left[M_t \cdot \tau^c_{t+1} w_{t+1}\right]$, increases. Hence, $\beta^*_t > 0$ could not have been an optimal choice. Q.E.D.

In words, a rational agent would be throwing away some of the value of the guarantee by holding some bonds in their new mandatory portfolio; they should instead hold more bonds in their non-mandatory portfolio. Notice that this argument implicitly assumes that " is not bound between zero and unity (i.e., there are no short-sale constraints in the non-mandatory private portfolio).

With $\beta^*_t = 0$, the new mandatory tax rate, τ^M, that is needed to produce an expected benefit R times the expected Social Security benefit equals

(7) $$\tau^M \equiv \frac{\psi \cdot \tau^s\left(1 + \bar{g}\right)}{\left(1 + \bar{e}\right)}$$

where $\bar{g}$ is the stationary expected wage growth rate. Moreover, the state-contingent tax equals, (6') $$\tilde{\tau}^c_{t+1} = \frac{\max\left\{0, \chi \cdot \tau^S_t w_t \cdot \left(1+g_{t+1}\right) - \tau^M w_t \cdot \left(1+e_{t+1}\right)\right\}}{w_{t+1}}$$

Post-Conversion Change in Unfunded Liabilities with a Minimum Guarantee and $\beta = 0$

To obtain intuitive and closed-form solutions, the analysis herein follows Feldstein and Samwick (1997) and many other papers who consider a riskless Social Security benefit. The net internal rate of return to Social Security, therefore, is set equal to the average wage growth rate, $g_t = \overline{g}$. In reality, of course, Social Security benefits are not risk-free since they are scaled to wage growth (as in Bohn, 1998, and Smetters, 2000*b*) and since they are subject to political choices. Historically, both the creation of Social Security benefits in the US and future increases in the benefit levels have sometimes been used to hedge, rather than reinforce, macroeconomic shocks (the Great Depression being the most obvious example). But in a mature social security system, the ability to continue to increase payroll taxes after a negative shock is more difficult. Hence, more of the risk will come from the wage indexation of Social Security benefits, which is being ignored in this paper.

The post-conversion percentage change in the unfunded liabilities in stochastic steady state is given by the ratio of the value of unfunded guarantee to the former unfunded benefit. For $ = 0,

$$\%\Delta_M = \left\{1 - \frac{E_t\left(M_t \cdot \tilde{\tau}^c_{t+1} w_{t+1}\right)}{E_t\left(M_t \cdot \tau^s_t w_{t+1}\right)}\right\} \cdot 100\%$$

(8) $$= \left\{1 - \frac{1+r}{1+\overline{e}} \cdot \psi \cdot E_t\left(M_t \cdot \max\left[0, \left(\frac{\chi(1+\overline{e})}{\psi} - 1\right) - e_{t+1}\right]\right)\right\} \cdot 100\%$$

$$\equiv \left(1 - \frac{1+r}{1+\overline{e}} \cdot \psi \cdot \hat{\Omega}\right) \cdot 100\%$$

where, as before, $M_t \equiv \lambda u'\left(c_{2,t+1}\right) / u'\left(c_{1,t}\right)$. The variable $\hat{\Omega}$ is the price of a one-period put option on a dollars worth of equities with a strike price of $\$1\left[\frac{\chi}{\psi}\left(1+\bar{e}\right)\right]$ the next period. The term $\frac{1+r}{1+\bar{e}}$ in (8) negates the attempt to arbitrage between the risk-free rate and the average equity return.

The strike price formula is intuitive. A higher expected benefit level (R), which requires a higher contribution rate J^{M}, lowers the implicit strike price. The reason is that more dollars are being contributed to the private accounts and so each dollar does not have to perform as well, ceteris paribus, for the same minimum benefit guarantee to be satisfied. Similarly, a higher guarantee level (P) effectively raises the strike price since each dollar must perform better ceteris paribus.

The parameters in equation (8) are directly observable, or can be computed using observable prices. The value of the put option can be priced exactly, without any additional assumptions about the preferences beyond nonsatiation, using the Black-Scholes (1973) option pricing theorem.[7] Price moments are assumed to fully incorporate all relevant information about preferences.

Table 1 reports values corresponding to equation (6) for various parameter choices. Following the 2000 Social Security Trustees Report, the annual average the risk-free rate, r, is set equal to 3.0 percent and the economy's expected growth rate, g, is set equal to 1.0 percent per year. Bonds, therefore, are assumed to stochastically dominate Social Security. Privatization is compared against a *solvent* Social Security system current-law benefits. This requires eventually increasing the OASDI payroll tax rate to about 19.25 percent. Following Feldstein and Samwick, the average annual return to equities, $\bar{e}$, equals 9 percent. The standard deviation of the first differences of

[7] Three implicit assumptions are being made. First, all computations ignore general equilibrium effects on prices and, therefore, correspond to only marginal changes. The property of risk aversion implies that the marginal cost of guarantee to generation t+1 increases with the absolute size of the guarantee. The focus on marginal analysis, therefore, underestimates of the guarantee cost and ignores negative price effects associated with higher liabilities. Second, because options for broad stock indices are not available with generational-frequency maturity dates, the use of the Black-Scholes option pricing formula might underprice the cost of a guarantee; options on broad indices that are traded are more expensive than the B-S formula predicts. Third, annuity markets are assumed to be perfect which is probably a close approximation (Mitchell, Poterba, Warshawsky, and Brown, 1999). Loads for adverse selection in the private annuity market should decrease after conversion as the average mortality risk becomes closer to the population average. The government could also decrease the load by requiring that some assets are annuitized.

logged real returns on the S&P500 since 1928 equals 0.20 and 0.164 since 1949. I conservatively chose 0.16 in all calculations. Each period represents 30 years and so the above annual rates are converted to their 30-year equivalents in all calculations herein.[8]

Privatization with a large minimum benefit guarantee can have difficulty in reducing unfunded liabilities. Consider the case $\{R = 1.0, P = 1.0, \$ = 0.0\}$. The variable *exp* shown in Table 1 equals $\$\bar{r} + (1-\beta)\bar{e}$, the portfolio's annualized expected net real rate of return, which equals 9 percent for these parameter choices. This case was considered by Feldstein and Samwick (1997) using a detailed simulation model. The model herein, despite being only two periods, closely replicates their "two percent" contribution level that they showed could be used to fully replace Social Security in the long run.[9] Without a minimum benefit guarantee, privatization would reduce the value of unfunded liabilities by 100 percent (since agents now bear the risk). Modifying their analysis to guarantee the existing benefit level, however, changes things dramatically. Unfunded liabilities are now reduced by only 17 percent.[10] The reason for the much smaller reduction is that a payroll tax of only two percent places a large demand on the equity premium which is not exploitable herein. Guaranteeing that this equity premium will, in fact, materialize, in turn, places a large unfunded liability on future generations.

Consider now the case $\{R = 5.0, P = 1.0, \$ = 0.0\}$ which is also highlighted in Table 1. Now the expected benefit is <u>five</u> times larger than the minimum benefit, but the reduction in unfunded liabilities only doubles to about 34 percent. The reason is that, while a higher expected benefit

[8] The choice of 30 years follows the two-period illustrative calculations presented in Feldstein and Samwick.

[9] Feldstein and Samwick were first to note how well the two-period framework is able to produce tax rates that are comparable to their more elaborate multi-period model.

[10] The 17 percent decrease in unfunded liabilities for the Feldstein-Samwick model is slightly higher than the 13 percent value report in Smetters (1999), mainly because the risk-free is higher herein.

lowers the strike price of the implicit put option, protection against very low returns is still the most valuable part of the option. Specifically, notice from Table 1, that the value of the put option, $\hat{\Omega}$, in the case {R = 1.0, P = 1.0, $ = 0.0} equals \$4.50. The implicit strike price in this case equals $\$1\left[\frac{\chi}{\psi}\left(1+\bar{e}\right)\right] = \$1\left(1+\bar{e}\right)$. In words, the market would charge \$4.50 to guarantee that a dollar invested today in stocks would be worth at least $\$1\cdot\left(1.09\right)^{30} = \$13.27$ in 30 years from now. With {R = 1.0, P = 1.0, $ = 0.0}, the implicit strike price is only $\$0.20\cdot\left(1+\bar{e}\right)$. As shown in Table 1, the market would only charge \$0.70 to guarantee that a dollar invested today in stocks would be worth at least $\$0.20\cdot\left(1.09\right)^{30} = \$2.65$ in 30 years from now. Although the value of the guarantee per dollar invested has decreased by six and a half times from the first case to the second, there are now five times more dollars being invested in the second case. The net impact, therefore, is quite small. The value of the guarantee would have to decrease by considerably more than xix and a half times from the first case to the second in order to have a big impact on unfunded liabilities; the reason it does not, however, reflects the value of insurance even for a relatively low strike price.

III. Minimum Benefit Guarantee of a Standardized Portfolio

Suppose now that the government only insurers a standardized portfolio consisting of some bonds ($ > 0). With $ > 0, the new mandatory tax rate, τ^{M}, that is needed to produce an expected benefit R times the expected Social Security benefit equals

(7') $$\tau^{M} \equiv \frac{\psi\cdot\tau^{s}\left(1+\bar{g}\right)}{\left[\left(1+r\right)\cdot\beta+\left(1+\bar{e}\right)\cdot\left(1-\beta\right)\right]} \quad .$$

The state-contingent tax is given by equation (6). The change in unfunded liabilities equals,

$$
\%\Delta_M = \left\{1 - \frac{E_t\left(M_t \cdot \tau_{t+1}^{c} w_{t+1}\right)}{E_t\left(M_t \cdot \tau_t^{s} w_{t+1}\right)}\right\} \cdot 100\%
$$

(8')

$$
= \left\{1 - \frac{(1+r)\cdot\psi\cdot(1-\beta)}{\left[(1+r)\cdot\beta + (1+\bar{e})\cdot(1-\beta)\right]} \cdot E_t\left(M_t \cdot \max\left[0, \left(\frac{\chi\left[(1+r)\cdot\beta + (1+\bar{e})\cdot(1-\beta)\right] - (1+r)\beta\psi}{\psi\cdot(1-\beta)} - 1\right) - e_{t+1}\right]\right)\right\} \cdot 10
$$

$$
\equiv \left(1 - \frac{(1+r)\cdot\psi\cdot(1-\beta)}{\left[(1+r)\cdot\beta + (1+\bar{e})\cdot(1-\beta)\right]} \cdot \hat{\hat{\Omega}}\right) \cdot 100\%
$$

where $\hat{\hat{\Omega}}$ is the price of a one-period put option on a dollars worth of equities with a strike price of

(9) $$\left(\frac{\chi\left[(1+r)\cdot\beta + (1+\bar{e})\cdot(1-\beta)\right] - (1+r)\beta\psi}{\psi(1-\beta)}\right) = \left(\frac{(\chi-\psi)(1+r)\beta}{\psi(1-\beta)} + \frac{\chi}{\psi}(1+\bar{e})\right)$$

provided that equation (9) is positive. It is possible that the expression in equation (9) could be negative if some bonds are held ($ > 0) and the expected benefit is large relative to the guarantee (R o P). In this case, the portion of investment making its way into bonds is large enough that even a zero *gross* return to stocks, (1+*e*), is enough to satisfy the guarantee. Since the gross return must always be nonnegative, the relevant strike price is zero and the minimum guarantee has no value.

Notice that when the guaranteed benefit level equals the expected benefit level $(\chi = \psi)$, the strike price equals $(1+\bar{e})$ but the value of the guarantee, $\%\Delta_M$, still tends to zero as the bond share approaches one ($ = 1). Intuitively, since the standardized portfolio invests only in risk-free bonds when $ = 1, the guarantee has no value since the mandatory tax rate, τ^M, is chosen so that the retirement benefit level exactly equals the guaranteed level.

If, however, $ = 1 and $\chi \neq \psi$, the "guarantee" may have value, but the actual payoff in period t+1 is already known in period t. In this case, the strike price is not determinant (zero divided by infinity) because the algebraic transformation to a stock put option no longer applies: stock performance is irrelevant with $ = 1. When $ = 1, the state-contingent tax rate becomes

(6")
$$\tilde{\tau}^{c}_{t+1} = \tau^{S}_{t} \cdot \left(1 + g_{t+1}\right) \cdot \max\left\{0, \chi - \psi\right\}$$
(for $ = 1)

and the change in unfunded liabilities equals

(8")
$$\begin{aligned} \%\Delta_{M} &= \left\{1 - \frac{E_t\left(M_t \cdot \tau^{c}_{t+1} w_{t+1}\right)}{E_t\left(M_t \cdot \tau^{s}_{t} w_{t+1}\right)}\right\} \cdot 100\% \\ &= \left\{1 - \max\left[0, \chi - \psi\right]\right\} \cdot 100\% \end{aligned}$$
(for $ = 1)

where, as before, the value of the option is evaluated at $g_{t+1} = \bar{g}$. Notice that unfunded liabilities are reduced by 100 percent if the expected retirement benefit exceeds the guaranteed level (R > P). But unfunded liabilities are only partially eliminated if the guaranteed level is larger (R < P).

Table 1 shows insuring only a standardized portfolio mixed with bonds is much more effective at reducing liabilities than the "over-saving" strategy considered above. Consider, for example, the case {R = 3.0, P = 1.0, $ = 0.50} in which 50 percent of assets in the standardized portfolio is held in bonds. Notice that the 10 percent mandatory tax rate in this case is the same as the case considered above, {R = 5.0, P = 1.0, $ = 0.0}, which incorporated a higher expected benefit but with no investment in bonds. Table 1 shows that unfunded liabilities are reduced by 65 percent in the case when bonds are held, {R = 3.0, P = 1.0, $ = 0.50}. In contrast, recall that unfunded liabilities are reduced by only 34 percent using the over-saving strategy, {R = 5.0, P = 1.0, $ = 0.0}.

The relative greater effectiveness of insuring only a standardized portfolio mixed with bonds can be motivated in several equivalent ways. Probably the easiest approach is to decompose a risk-free return into two offsetting risky returns. Consider a stock whose price is $1 today, and consider a put stock option a and call stock option for this stock with a maturity date one period from now and a strike price \$1(1+*r*). From the classic put-call parity relationship (or, equivalently, from the first-order conditions (4) and (5)), it can be shown that taking a long position in the put option and a short position in the call option is equivalent to holding a bond with a gross return of \$1(1+*r*). In effect, when generation *t* holds a bond, therefore, it extracts the put option from generation *t*+1 but also hands them over the call option. This put option, however, is not valued by generation *t* because it's presence simply reduces the value of the put option that generation *t* would have received from generation *t*+1 in the form of a benefit guarantee (hence, the reason why generation *t* would never hold bonds voluntarily in their mandatory portfolio). The *net* effect of holding bonds, therefore, is for generation *t* to transfer a call option to generation *t*+1 – an inter-generational transfer that does not exist with the over-saving strategy.

The net inter-generational transfer of a call option from generation *t* to generation *t*+1 is quite powerful. In fact, notice from Table 1 that if the standardized portfolio contains enough bonds, the unfunded liabilities are completely eliminated – an event which is not possible with over-saving.

A Partial Conversion to Private Accounts: The Bush Plan

Recently, US presidential candidate G.W. Bush announced a broad outline of a plan to avoid the impending increase in the payroll tax rate (or decrease in benefits) from the current level of 12.4 percent of payroll (including DI) to over 19 percent of payroll by the year 2075.[11] His approach would set aside assets today to help pay for future benefits. Although the exact details of his plan have not been specified yet, the following design elements appear to be close to what the plan architects have in mind. People would be allowed to divert some of their Social Security payroll tax – about two to three percentage points – to private accounts which could be invested in stocks and

[11] This projection is made in the "intermediate cost" scenario in the 2000 Social Security Trustees Report.

bonds. The Bush plan protects the full Social Security benefits for those above some middle age who do not choose to divert some of their payroll tax.[12] For those who choose partial diversion, they would continue to pay between nine and ten percentage points of their existing payroll tax into Social Security to help pay for contemporaneous benefit obligations; any shortfall below Social Security's contemporaneous cost rate would be financed from projected budget surpluses (i.e., a current tax expenditure).[13] (Conceptually, it makes no difference if budget surpluses were instead used to pay for the contributions to individual accounts.) People who choose partial diversion would still receive a future benefit from Social Security, but it would be reduced to reflect their smaller contributions.

Assuming a diversion equal to three percent of payroll, the private account of a younger person starting out in Social Security would produce an average retirement benefit equal to a little more than 40 percent of the current benefit level if the account was only invested in risk-free assets earning a real annual return of 3.0 percent per year.[14] Moreover, this person would receive a reduced benefit from Social Security equal to about two-thirds of the current legal benefit level. The total combined benefit, therefore, would be slightly larger than the current benefit level. For relatively older workers who choose to participate, they would receive a smaller benefit from their new mandatory private account along with a larger benefit from Social Security, keeping their combined benefit a little above the current level. Interestingly, the Bush campaign has not announced an explicit minimum benefit guarantee and the calculations herein suggest that they really don't need

[12] It appears that the Bush plan would "bond" existing Social Security benefits, raising them to the same legal status as Treasury securities. German public insurance benefits have also been bonded by Germany's highest court.

[13] Chile used budget surpluses to pay for the conversion of its public pension plan during the 1980s.

[14] As a rough check, note that $3(1+r)^{30} / 12(1+g)^{30} = 0.45$ for $r = 0.03$ and $g = 0.01$. Note that the risk-free rate in more recent years has exceeded four percent.

to in order to protect the existing benefit level. Of course, many younger people might choose to hold some stocks in their mandatory account, but they would bear the basis risk.

IV. A Fixed Benefit Guarantee

An alternative to provided a minimum benefit guarantee is to simply promise a *fixed* benefit equal to P times the current Social Security benefit. The "conversion" process is the same as before, except now the accumulation of assets are held by the government in a trust fund so that they can strip off any excess returns, and subsidized low returns, to produce a fixed defined benefit.[15] The new mandatory tax rate is again given by equation (7') and $ fraction of these taxes are deposited in bonds (i.e., debt reduction) with the other (1-$) deposited in equities.

The nature of the guarantee is, therefore, changed from a one-sided bet, where future tax payers only bear the downside risk, to a two-sided bet where future taxpayers also receive the potential upside if equities outperform expectation. In fact, conceptually, this change in the guarantee structure is the only really important change; everything else remains the same.[16] The new state-contingent tax, therefore, is similar to equation (6) except without the max operator:

$$\text{(6''')} \qquad \tau_{t+1}^{c} = \frac{\chi \cdot \tau_t^{SS} w_t \cdot \left(1+g_{t+1}\right) - \tau^{M} w_t \cdot \left[\left(1+r_{t+1}\right)\cdot \beta_t + \left(1+e_{t+1}\right)\cdot\left(1-\beta_t\right)\right]}{w_{t+1}}$$

The change in unfunded liabilities from greater funding, therefore, equals

[15] Instead, the assets could be stored in private accounts and the government could subsidize the downside and confiscate excess returns. But, for a fixed benefit, that approach would not be worth even the smallest transaction costs.

[16] I do not examine the relative merits of the defined-contribution model versus the defined-benefit model outside the guarantee issue. Other relevant issues (e.g., job lock) tend to be the most important for *private* pensions.

(10)

$$
\begin{aligned}
\%\Delta_F &= \left\{1-\frac{E_t\left(M_t\cdot\tau^c_{t+1}w_{t+1}\right)}{E_t\left(M_t\cdot\tau^s_t w_{t+1}\right)}\right\}\cdot 100\% \\
&= \left\{1-\frac{(1+r)\cdot\psi\cdot(1-\beta)}{\left[(1+r)\cdot\beta+(1+\bar{e})\cdot(1-\beta)\right]}\cdot E_t\left(M_t\cdot\left[\frac{\chi\left[(1+r)\cdot\beta+(1+\bar{e})\cdot(1-\beta)\right]-\psi(1+r)\beta}{\psi(1-\beta)}-\left(1+e_{t+1}\right)\right]\right)\right\} \\
&= \left(1+\frac{(1+r)\cdot\psi}{\left[(1+r)\cdot\beta+(1+\bar{e})\cdot(1-\beta)\right]}-\chi\right)\cdot 100\%
\end{aligned}
$$

Proposition 2. $\%\Delta_F > \%\Delta_M$ for $\$ < 1$, I.e., for identical parameters, prefunding leads to a greater reduction in unfunded liabilities than privatization when some stocks are being held.

To sketch a proof, note that for any variable *x*, $x = \max[0,x] + \min[0,x]$ Y $\max[0,x] \geq x$ Y $E_t\left(M_t\cdot\max[0,x]\right) > E_t\left(M_t\cdot x\right)$. Now compare the second lines in equations (8') and (9) and substitute the expression in the max operator in (8') for *x*. Q.E.D.

Intuitively, the two-sided bet associated with prefunding can be decomposed into a long position in a put stock option (the max operator in the above proof) and a short position in a call option (the min operator in the above proof) with the same strike price, as shown in equation (9). Prefunding, like privatization, gives generation *t*+1 a long position in a put option which is extracted from generation *t*. However, unlike privatization, prefunding also transfers a call option from generation *t* to generation *t*+1 as partial compensation for the put option.

In general, if the implicit strike price shown in equation (9) equals \$1(1+*r*) then, by the first-order conditions (5) and (6) (or, equivalently, put-call parity), the put and call options have equal worth and so prefunding fully reduces existing liabilities by 100 percent. Notice that this case is equivalent to holding only bonds, and both approaches reduce unfunded liabilities by 100 percent, as shown in the case {R = 1.0, P = 1.0, $ = 1.0} in Table 1. However, unlike with bond holdings, prefunding a fixed benefit can actually lead to a reduction in unfunded liabilities *above* 100 percent, as shown in Table 1. This occurs when the expected benefit level is chosen sufficiently larger than the guaranteed benefit (i.e., R o P) and so the value of the strike price in equation (9) actually falls *below* \$1(1+*r*). The value of the call option transferred from generation *t* to generation *t*+1 actually becomes more valuable than the put option that generation *t* extracts from generation *t*+1.

With this background in mind, let's consider a few examples from Table 1.

First, notice from equation(10) that setting the expected benefit level equal to the guaranteed benefit level (R = P) does not lead to a 100 percent reduction in unfunded liabilities *unless* the bond share of assets in the standardized insured portfolio equals one ($ = 1). As shown in Table 1 for the case {R=1, P =1, $ = 0}, prefunding the fixed benefit only leads to a 18 percent reduction in unfunded liabilities, compared to a 17 percent reduction when only the minimum benefit guarantee is in place, as with privatization. The reason is that average equity return is being relied on heavily to provide the retirement benefit and so the promise to give generation *t*+1 any upside potential – above the expected return to equities – is not very valuable relative to the minimum guarantee being extracted from generation *t*+1. In other words, the call option is not very valuable relative to the put option because the relevant strike price, $\$1(1+\bar{e})$, is substantially larger than $\$1(1+r)$.

This result should give policymakers – and budget authorities – some pause. Under traditional budgetary scoring rules which focus only on expected returns, it would appear that Social Security could be fully replaced with a two-percent payroll tax invested in equities. Table 1, however, shows that the actual risk-adjusted change in liabilities is quite small, and only marginally better than the change in liabilities that can be achieved via privatization.

Second, now consider the case {R = 3.0, P = 1.0, $ = 0.5} highlighted in Table 1. In this case, prefunding a fixed benefit reduces unfunded liabilities by 93 percent whereas privatization with a minimum guarantee reduces unfunded liabilities by only 65 percent. The reason for the larger change when prefunding the fixed benefit is that the additional implicit call option given to generation *t*+1 is quite valuable at R = 3.0 which is consistent with a smaller strike price.

However, these calculations assume no storage risk on the part of government. Suppose that there is a 50 percent chance that the government spends the trust fund "through the back door." As noted earlier, some observers believe that the government currently spends much (if not the vast majority) of trust fund surpluses by focusing on a unified budget measure. Also suppose, somewhat conservatively, that if the government spends the trust fund, it will only pay the existing benefit level (P = 1), even if earlier promised more (P > 1). In this case, the magnitude of the reduction in unfunded liabilities associated with prefunding the fixed benefit is cut in half, as shown in the rightmost column in Table 1. The 93 percent reduction, noted above, is reduced to 46 percent, and prefunding the fixed benefit results in a smaller reduction in liabilities relative to privatization.

Now consider the case {R = 5.0, P = 0.75, $ = 0.0} highlighted in Table 1. In this case, the Social Security benefit is reduced to three-quarters of the current level and prefunding this smaller benefit reduces unfunded liabilities by 117 percent without storage risk, and by 58 percent with a 50 percent storage risk. In contrast, privatization with a minimum benefit guarantee equal to three-quarters of the current benefit level reduces unfunded liabilities by only 49 percent. In this case, prefunding the existing benefit level reduces liabilities more even with a modest storage risk.

V. Conclusion

[To do based on comments received]

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Table 1
Change in Unfunded Liabilities

(See parameter assumptions table and variable definitions table on the next two pages)

R	P	$	*exp*	J^M	%)$_M$	%)$_F$	$\hat{\Omega}$	%)$_{F,D}$
1.0	0.75	0.0	0.09	0.020	41.0	43.3	3.2	21.6
1.0	0.75	0.5	0.06	0.033	53.8	55.9	3.0	28.0
1.0	0.75	1.0	0.03	0.107	100.0	125.0	0.0	62.5
1.0	1.00	0.0	0.09	0.020	17.0	18.3	4.5	9.1
1.0	1.00	0.5	0.06	0.033	29.9	30.9	4.5	15.5
1.0	1.00	1.0	0.03	0.107	100.0	100.0	0.0	50.0
2.0	0.75	0.0	0.09	0.039	48.6	61.6	1.4	30.8
2.0	0.75	0.5	0.06	0.066	70.9	86.9	0.9	43.4
2.0	0.75	1.0	0.03	0.214	100.0	225.0	0.0	112.5
2.0	1.00	0.0	0.09	0.039	27.7	36.6	2.0	18.3
2.0	1.00	0.5	0.06	0.066	51.9	61.9	1.6	30.9
2.0	1.00	1.0	0.03	0.214	100.0	200.0	0.0	100.0
2.0	1.25	0.0	0.09	0.039	5.3	11.6	2.6	5.8
2.0	1.25	0.5	0.06	0.066	30.5	36.9	2.2	18.4
2.0	1.25	1.0	0.03	0.214	100.0	175.0	0.0	87.5
2.0	1.50	0.0	0.09	0.039	-17.9	-13.4	3.2	-6.7
2.0	1.50	0.5	0.06	0.066	7.6	11.9	3.0	5.9
2.0	1.50	1.0	0.03	0.214	100.0	150.0	0.0	75.0
3.0	0.75	0.0	0.09	0.059	50.5	79.9	0.9	39.9
3.0	0.75	0.5	0.06	0.099	79.5	117.8	0.4	58.9
3.0	0.75	1.0	0.03	0.321	100.0	325.0	0.0	162.5
3.0	1.00	0.0	0.09	0.059	32.5	54.9	1.2	27.4
3.0	1.00	0.5	0.06	0.099	64.5	92.8	0.8	46.4
3.0	1.00	1.0	0.03	0.321	100.0	300.0	0.0	150.0
3.0	1.50	0.0	0.09	0.059	-8.5	4.9	2.0	2.4
3.0	1.50	0.5	0.06	0.099	27.9	42.8	1.6	21.4
3.0	1.50	1.0	0.03	0.321	100.0	250.0	0.0	125.0
5.0	0.75	0.0	0.09	0.098	48.6	116.5	0.6	58.2
5.0	0.75	0.5	0.06	0.165	100.0	179.7	0.0	89.8
5.0	0.75	1.0	0.03	0.535	100.0	525.0	0.0	262.5
5.0	1.00	0.0	0.09	0.098	33.7	91.5	0.7	45.7
5.0	1.00	0.5	0.06	0.165	82.9	154.7	0.2	77.3
5.0	1.00	1.0	0.03	0.535	100.0	500.0	0.0	250.0
5.0	1.50	0.0	0.09	0.098	0.0	41.5	1.1	20.7
5.0	1.50	0.5	0.06	0.165	51.1	104.7	0.6	52.3
5.0	1.50	1.0	0.03	0.535	100.0	450.0	0.0	225.0

(Continued)

Table 1 (Cont.)
Variable Definitions

Variable	Definition
R	Expected retirement benefit in private account = R × Social Security benefit
P	Guaranteed benefit in private account = P × Social Security benefit
$	Share of assets in private account invested in bonds
exp	$= \beta r + (1-\beta)\bar{e}$, i.e., the expected net annual real return to private account
J^{M}	Mandatory contribution (tax) rate for the new private account
$\%)_{M}$	Percent change in unfunded liabilities with the minimum benefit guarantee
$\%)_{F}$	Percent change in unfunded liabilities with the fixed benefit guarantee, assuming no storage risk
$\hat{\Omega}$	Value of implicit put option for the minimum benefit guarantee
$\%)_{F,D}$	Percent change in unfunded liabilities with the fixed benefit guarantee, assuming that there is a 50 percent chance that trust fund assets are spent elsewhere (and, if spent, only the original Social Security benefit [P=1] is delivered, regardless of the previously stated value of P).
$\bar{e}$	Expected annual real rate of return to equities
r	Real annual risk-free return
$\bar{g}$	Expected annual real rate of wage growth
F	Standard deviation of the first differences of logged real returns on the S&P500

Table 1 (Cont.)
Parameter Assumptions

Parameter	Value
$\bar{e}$	0.09
r	0.03
g	0.01
F	0.16
R	(varies)
P	(varies)
$	(varies)
exp	(varies)