Guarantee Costs and Portfolio Selection in Guaranteed, Privatized Social Security Accounts, With and Without Inflation Indexing

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This study demonstrates the practical application of option pricing theory to calculate the cost of providing guarantees for privatized social security accounts. We examine privatized social security from the perspective of a participant. If there are no guarantees, the participant is likely to invest in some diversified mix of stock and bond funds. Using an option pricing model we show that if the government guarantees the principal, rational participants will shift their entire contribution to the riskiest fund available for investment, which in turn will maximize the cost of providing the guarantee. We find that the cost of the guarantee is substantially lower for younger participants than for older participants if the guaranteed principal is not indexed for inflation, but the difference is small if the guaranteed principal is indexed for inflation. Our findings suggest that the government needs to offer only one mix of funds for investment in guaranteed accounts, and to minimize guarantee costs, it would guarantee only the principal. Alternatively, it could take a more age-neutral approach by guaranteeing the inflation-indexed principal.

INTRODUCTION

President George W. Bush and others have advocated partial privatization of the social security system. President Bush mentioned it during his presidential campaigns in 2000 and 2004, and his State of the Union Addresses in January 2005 and 2006. Besides President Bush, other politicians such as Moynihan (2000) have expressed strong opinions on this issue as well. A Presidential Commission investigated privatization in 2002. Although discussion of this topic has quieted in recent months, the state of the social security program suggests that changes will have to be made in the system. The privatization plans that have been discussed would divert a portion of the payroll tax to privatized social security accounts that will be managed by individual participants. The privatization proposals have generated a lot of opposition, mainly because they remove

the guarantee of payments that is a part of the current social security system. Adding a government guarantee to the current privatization proposal could make the privatization of social security more acceptable.

The cost and implications of providing a guarantee would become important issues, if the government is going to guarantee privatized social security accounts. Option pricing theory gives us the methodology to calculate the cost of different types of guarantees. We show how option pricing models can be used to calculate the cost of the guarantee for different types of investment portfolios, both with and without indexing the guaranteed amount for inflation. Restructuring social security is a complex issue, and most of the discussion on the merits and shortcomings of privatization has focused on macroeconomic considerations. We examine the issue from the perspective of a participant in the social security system, and the choices he or she has to make in allocating the social security contribution to a mix of investments[1].

Several studies have focused on individual decisions in a privatized social security system and come to mixed conclusions. Nataraj and Shoven (2003, p.352) conclude that the "optimal (utility maximizing) structure for Social Security involves a substantial individual-accounts component, even for highly risk-averse participants." Burtless (2003) on the other hand concludes that the retirement risk of Privatized Social Security accounts is quite large, larger than is likely to be tolerated. Cronqvist and Thaler (2004) survey the choices made by participants in the Swedish Privatization Plan, and find that those choices are heavily influenced by the design of the system and its promotion. They also find that, "portfolios individuals formed themselves seemed heavily influenced by recent returns (an extrapolation bias), and by a preference for investing close to home (a "familiarity" bias). Feldstein, Ranguelova and Samwick (2000) have analyzed a variety of government guarantees including one where individuals invest a part of their social security contribution in a 60-40 mix of stocks and bonds, with the government supplementing the income of retirees, if necessary, to prevent it from dropping below some minimum. They conclude that providing such a guarantee would impose relatively little risk on future taxpayers. Feldstein and Ranguelova (2001) have analyzed market-based guarantees where individuals guarantee their contributions by buying zero-cost collars from financial institutions, which requires individuals to know their future earnings in advance[2]. As Kale and Perry (2005) pointed out, "zero cost collars also require individuals to give up the outstanding up-side opportunities of owning stocks, which in some ways defeats the purpose of allowing individuals to invest a part of their social security contribution in stocks." Bodie (2000) discusses a portfolio of call options and risk-free bonds that an individual can construct for guaranteeing a minimum rate of return.

Privatization proposals for the social security system tout the opportunity available in the stock market for earning higher returns than those offered by the government. To mitigate the risk associated with stock market investments, President Bush in his State of the Union Address (2006) suggested the possibility of some protection for privatized accounts when he said, "We'll make sure there are good options to protect your investments from sudden market swings on the eve of your retirement." Unfortunately, the lack of clarity regarding the "options," that the President referred to, continues to contribute to the uneasiness about privatized social security accounts. Kale and Perry (2005) proposed and examined the value and cost of one possible option, namely a

government guarantee of the principal contributed to a privatized account. They conclude that the cost of providing a guarantee to a privatized account that is invested in the stock market, is in the range of four to thirteen percent of the amount contributed, and depends on the time to retirement for the participant. They also show that if the guaranteed principal is indexed for inflation, the cost of the guarantee is substantially higher and does not vary much with time to retirement. In this study we examine the effect on the value of the guarantee and its cost, if individuals can select investment portfolios from index funds with different risk characteristics.

A PRIVATIZED SOCIAL SECURITY ACCOUNT

Since our interest is in portfolio selection and guarantee costs in a government guaranteed privatized social security system, we will assume a simple design for privatized accounts and focus only on the characteristics of the system that will influence portfolio selection and guarantee costs.

We assume that:

1. Individual participants contribute $1,000 of their payroll to a Privatized Social Security Account[3].
2. Individuals may select any combination of the following four funds for investing their contribution to the Privatized Social Security Account:
   (a) U.S. Treasury bill fund
   (b) Long-term government bond fund
   (c) Large-company stock fund
   (d) Small-company stock fund
3. The money will be withdrawn at retirement.

Table 1 shows the risk and return characteristics of the asset classes of that correspond to the funds (Ibbotson Associates, 2003).

TABLE 1
SUMMARY STATISTICS FOR ANNUAL RETURNS, 1926-2002

	Average Return (%)	Standard Deviation (%)
U.S. Treasury bills	3.8	3.2
Long-term govt. bonds	5.8	9.4
Large-company stocks	12.2	20.5
Small-company stocks	16.9	33.2

PORTFOLIO SELECTION WITHOUT A GUARANTEE

If there are no guarantees provided by the government, individuals will select a portfolio from the available funds based on their personal tolerance for risk and their ability to bear risk with the expectation of a higher return. Typically older individuals will select portfolios with lower risk and younger individuals will pick portfolios with higher risk. We can use mean-variance analysis (Markowitz, 1952) to select the best portfolios at different levels of risk. Using the data in Table 1 for estimates of expected return and standard deviation, and the correlation between the asset classes from Ibbotson Associates' 2003 Yearbook, we construct the mean-variance efficient portfolios shown in Table 2 for four different levels of risk.

The portfolios are:

1. A minimum risk portfolio.
2. A low risk portfolio which maximizes expected return, given risk similar to a long term bond portfolio.
3. A medium risk portfolio which maximizes expected return, given risk similar to large company stock portfolio, and
4. A portfolio which maximizes the expected rate of return.

All four portfolios shown in Table 2 have been constructed with a no short-sales constraint.

TABLE 2
OPTIMAL PORTFOLIOS WITHOUT A GUARANTEE

	Minimum Risk	Low Risk	Medium Risk	High Risk
Asset Weights (%)				
U.S. Treasury bills	94.67	19.63	0.00	0.00
Long-term govt. bonds	3.44	44.89	22.31	0.00
Large-company stocks	0.41	19.43	38.59	0.00
Small-company stocks	1.48	16.05	39.10	100.00
Summary Statistics (%)				
Average Return	4.13	8.46	12.64	16.95
Standard Deviation	3.08	10.00	20.00	33.19
Yield	2.04	3.08	2.19	1.12

The Minimum-Risk portfolio in Table 2 is the portfolio with the lowest standard deviation that can be constructed from the four funds. Its expected return of 4.13% is higher than the average return of 3.8% for T-Bills (Table 1), and its standard deviation of 3.08% is lower than the standard deviation of 3.2% for T-Bills, which demonstrates the power of diversification. The dividend yield for this portfolio is 0.02%, calculated as a weighted average of the dividend yields for the individual funds. The dividend yield for

the S&P500 index, 1.74%, is used for large-company stocks, and the dividend yield for the Russell 2000 index, 1.12%, is used for small-company stocks (Wall Street Journal, December 20, 2004).

The Low-Risk portfolio in Table 2 has been constructed with a standard deviation of 10%, approximately the standard deviation of long-term government bonds. The Medium- Risk portfolio has been constructed with a standard deviation of 20%, which is slightly less than the 20.5% standard deviation of large-company stocks (Table 1). The High-Risk portfolio is the efficient portfolio for an individual who wants to earn the highest possible return regardless of risk. It contains only small-company stocks.

PORTFOLIO SELECTION WITH A GUARANTEED PRINCIPAL

Assuming that the government guarantees the principal contributed to the privatized social security account, the participant in the system will receive at least $1,000 at retirement. If the investment does poorly and has a total value less than $1,000, the government will make up the shortfall between the $1,000 principal contributed and the total value of the investment. If the investment does well and its total value is greater than $1,000, the participant will receive the total value at retirement, which consists of the $1,000 principal contributed plus accumulated income and any capital gains. The payoff pattern on retirement date for this guaranteed account is identical to the payoff pattern for a protective put.

With the guarantee, the participant in effect owns the $1,000 portfolio purchased with the contribution, plus a put option on the portfolio. The total value of the investment is the sum of the values of the $1,000 portfolio and the put option. A rational individual will maximize the total value of the investment. Since the value of the initial portfolio purchased is fixed at $1,000, the participant will maximize the total value of the investment by maximizing the value of the put option on the portfolio. The put option value is also the cost of the guarantee provided by the government. Since the investment is held to the retirement date, the put option is a European option, and we use the Black-Scholes option pricing model for calculating its value.[5]

The put option is an at the money option with a strike price of $1,000. We calculate the values of the put options on the four portfolios shown in Table 2 for times to retirement that range from 5 years to 30 years. The dividend yield and standard deviation of portfolio return shown in Table 2 are used as inputs to the Black-Scholes model adjusted for dividends. For riskless rates we use the term structure of interest rates based on treasury issues (Wall Street Journal, December 20, 2004) shown in Table 3, where the time to retirement corresponds to the term.

TABLE 3
TERM STRUCTURE OF INTEREST RATES

Time to Retirement (Years)	Rate (%)
5	3.56
10	4.26
15	4.72
20	4.92
25	4.90
30	4.85

The calculated values of the put options for the four portfolios are shown in Table 4. For example, for a participant who has 30 years to retirement and invests $1,000 in a medium-risk portfolio, the value of the put option is $32.40. This implies that the cost to the government will be 3.24% of the amount contributed by this individual. For a participant with 30 years to retirement, the last row of the table shows that the value of the put option varies from close to zero for the minimum-risk portfolio to $98.12 for the high-risk portfolio. For a participant with 5 years to retirement, the first row of the table shows that the value of the put option varies from $0.10 for the minimum-risk portfolio to $206.96 for the high-risk portfolio. For the range of times to retirement shown, the guarantee has the lowest value for a young individual who invests in a minimum-risk portfolio and has the highest value for an older individual who invests in a high-risk portfolio.

TABLE 4
VALUE OF PUT OPTION FOR A $1,000 CONTRIBUTION, WHEN THE PRINCIPAL IS GUARANTEED

Time to Retirement (Years)	Minimum-Risk Portfolio		Low-Risk Portfolio		Medium-Risk Portfolio		High-Risk Portfolio	
	($)	(%)	($)	(%)	($)	(%)	($)	(%)
5	0.10	0.01	29.75	2.97	108.97	10.90	206.96	20.70
10	0.00	0.00	14.35	1.44	93.53	9.35	201.58	20.16
15	0.00	0.00	5.63	0.56	68.63	6.86	168.03	16.80
20	0.00	0.00	2.36	0.24	50.51	5.05	137.09	13.71
25	0.00	0.00	1.25	0.12	40.16	4.02	115.92	11.59
30	0.00	0.00	0.70	0.07	32.40	3.24	98.12	9.81

FIGURE 1
COST OF GUARANTEEING THE PRINCIPAL

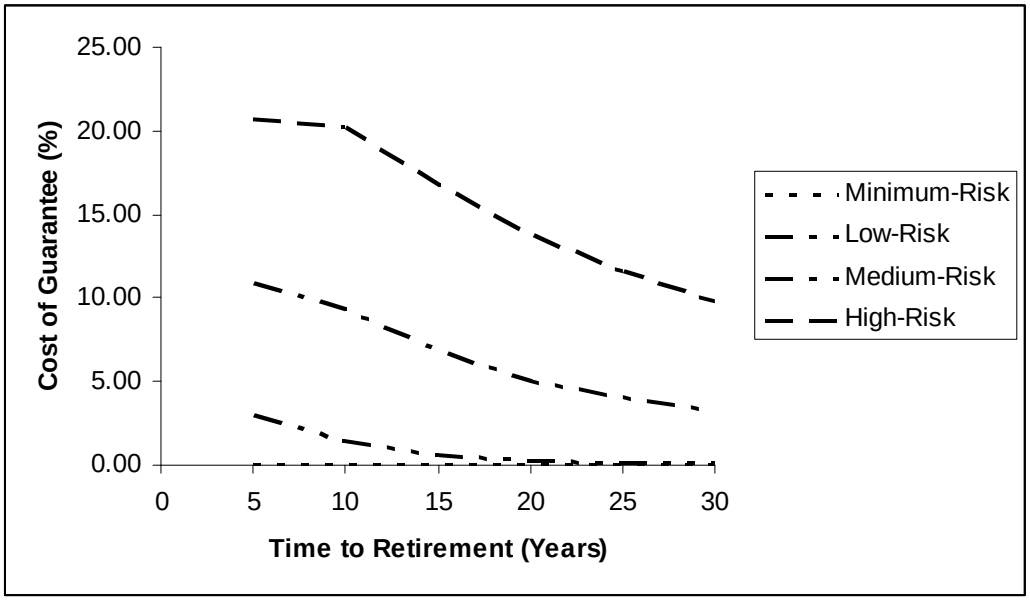


Figure 1 compares the cost of the guarantee for different age groups and portfolios. It shows that for a given level of risk the cost of the guarantee falls as the time to retirement rises. This phenomenon is a result of the decrease in the present value of the strike price of the put option as time to expiration increases, which becomes dominant for longer horizons. Further, for a given time to retirement, the cost of the guarantee rises with risk.

A rational individual will maximize the sum of the values of the portfolio purchased ($1,000) and the put option. Therefore, each participant will select the high-risk portfolio regardless of age since that maximizes the value of the put option. Without the guarantee, a young participant with 30 years to retirement might have selected the high-risk portfolio anyway. However, without the guarantee an older participant with 5 years to retirement is more likely to have selected a lower-risk portfolio, and the existence of the guarantee changes this individual's selection to a high-risk portfolio[6]. If the government did offer this kind of opportunity to all participants, the cost to the government will about twice as high for an individual with 5 years to retirement (20.70%) than for an individual with 30 years to retirement (9.81%), assuming that all participants select the high risk portfolio.

To control the cost of the guarantee, the government can restrict the portfolio choices that are made available to participants in the system. The cost of guaranteeing the minimum-risk portfolio is virtually zero. It is about 98% invested in treasuries (Table 2), and would be very similar to the model currently followed by some countries. The cost of guaranteeing a low-risk portfolio varies from 0.07% for an individual with 30 years to retirement to 2.97% for an individual with 5 years to retirement. The cost of the guarantee is still extremely low for young participants. The cost for all participants rises substantially as the risk of the portfolio increases further.

Another method of controlling the cost of the guarantee would be to cap it. In some ways this would be more equitable for all participants. For example, a 10% limit on the cost of the guarantee would allow an individual with 30 years to retirement to select the

high risk portfolio with its higher expected rate of return, an individual with 10 to 25 years to retirement to select the medium-risk portfolio, and an individual with 5 years to retirement to select the low-risk portfolio. To allow more choices, the variety of portfolios available could be increased.

PORTFOLIO SELECTION WITH A GUARANTEED PRINCIPAL INDEXED FOR INFLATION

To provide some protection to the real return that participants earn on their social security contribution, the guarantee could be made on the contributed principal indexed for likely inflation. This will also make the program more attractive to all participants. We get the estimate for the potential inflation from the difference in yields on treasury bonds and Treasury Inflation Protection Securities. For a five-year term it was around 2.62% (Wall Street Journal, December 20, 2004). Assuming that inflation over the five years is a constant 2.62% per year, the guaranteed amount indexed for inflation over five years is $1,138.05. This value is now the strike price for the put option. Table 5 shows estimates of the inflation rate and the corresponding values of the inflation indexed principal for time to retirement from 5 to 30 years.

TABLE 5
INFLATION ESTIMATES AND THE INFLATION-INDEXED PRINCIPAL, FOR A $1,000 CONTRIBUTION

Time to Retirement (Years)	Inflation Rate (%)	Indexed Principal ($)
5	2.62	1,138.05
10	2.62	1,295.15
15	2.74	1,500.01
20	2.86	1,757.64
25	2.92	2,053.50
30	2.94	2,385.20

Table 6 shows the values of the put option, recalculated with the inflation indexed principal as the strike price. When compared to the values in Table 4, the put values in Table 6 are substantially higher across the board, as a result of the substantially higher strike prices for the options. The increase is much greater for longer times to retirement than shorter ones.

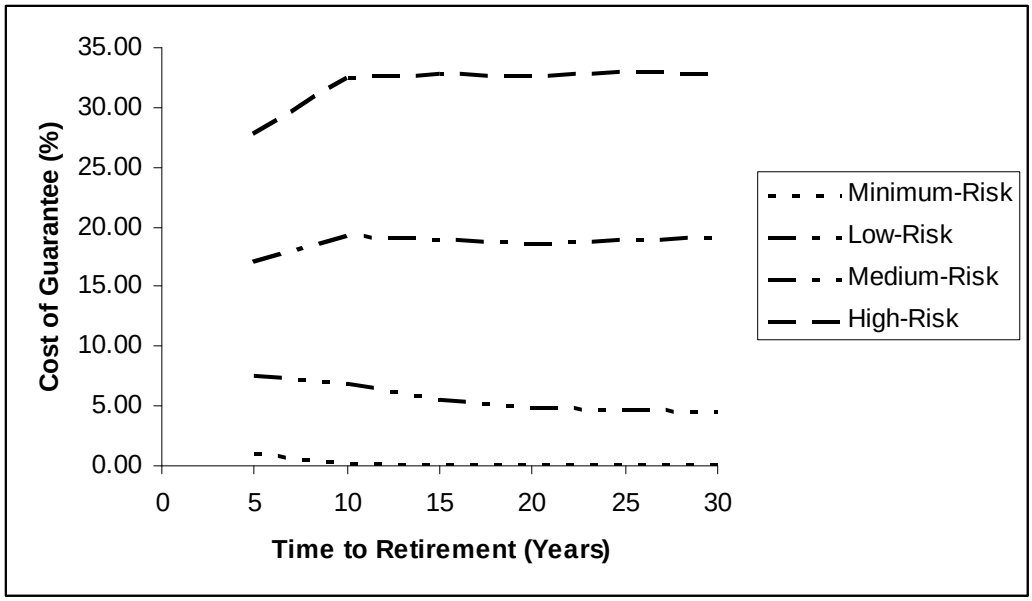
TABLE 6
VALUE OF PUT OPTION FOR A $1,000 CONTRIBUTION, WHEN THE INFLATION-INDEXED PRINCIPAL IS GUARANTEED

Time to Retirement (Years)	Minimum-Risk Portfolio ($)	Minimum-Risk Portfolio (%)	Low-Risk Portfolio ($)	Low-Risk Portfolio (%)	Medium-Risk Portfolio ($)	Medium-Risk Portfolio (%)	High-Risk Portfolio ($)	High-Risk Portfolio (%)
5	9.72	0.97	75.28	7.53	171.21	17.12	278.15	27.81
10	1.64	0.16	68.40	6.84	192.31	19.23	324.58	32.46
15	0.20	0.02	55.26	5.53	188.65	18.86	328.51	32.85
20	0.04	0.00	47.93	4.79	185.48	18.55	326.37	32.64
25	0.02	0.00	46.81	4.68	189.50	18.95	329.81	32.98
30	0.01	0.00	45.68	4.57	191.23	19.12	328.57	32.86

For the minimum-risk and low-risk portfolios the put values decrease as time to retirement increases in Table 6, just as they do in Table 4. However, in contrast to Table 4, the Table 6 put values generally increase as time to retirement increases for the medium-risk and high-risk portfolios. For a participant who has 30 years to retirement and selects the high risk portfolio, the value of the put option and the corresponding cost of the guarantee increases more than threefold from 9.81% to 32.86%, when the guaranteed principal is indexed for inflation. Figure 2 compares the cost of the inflation indexed guarantee for different age groups and portfolios.

The difference between the cost of the guarantee for younger and older participants is much smaller when the guarantee is indexed for inflation. For example if the guarantee is indexed for inflation and portfolio selection is restricted to a low-risk portfolio, the cost of the guarantee lies in a small range from 4.57% to 7.53% of the amount contributed. For a medium-risk portfolio the costs range from 17.12% to 19.12% of the amount contributed[7].

FIGURE 2
COST OF GUARANTEEING THE INFLATION-INDEXED PRINCIPAL



IMPLICATIONS

The design of a guaranteed privatized social security system needs to account for the following implications of the portfolio selection choices that will be made by rational participants in such a system, and the resulting cost of the guarantees:

1. Since rational participants will select only the riskiest portfolio given a choice of portfolios, the government needs to offer only one portfolio for investment.
2. By offering a low to medium risk portfolio of stocks and bonds as the fund available for investment, the government could limit the cost of the guarantee to acceptable levels.
3. To keep the cost of the guarantee low, the government could further choose to guarantee only the contributed principal. This approach involves a trade-off, where the government gives participants the opportunity for a better upside return on social security contributions, but takes away the inflation indexing which is a part of the current system.
4. Since the cost of guaranteeing older participants is substantially higher than guaranteeing young participants when only the contributed principal is guaranteed, the government could minimize start-up costs for a privatized system by starting the program with young participants only. Of course, as the participants age, the cost of guaranteeing their contributions will rise.
5. Guaranteeing the inflation-indexed principal increases the cost of the guarantee substantially across the board, but far more so for young participants than for older ones. A relatively age-neutral policy could be implemented by providing a low or medium risk portfolio for investment and guaranteeing the inflation-indexed principal. While such a policy is more equitable in some ways, it would be substantially more expensive for the government than the other policies described above.
6. Congress would have the choice of: (1) funding the guaranteeing cost up front, each time a contribution is made by a participant, or (2) simply making a promise to fulfill the guarantee at a future date from future revenues if needed. The second approach would result in an intergenerational transfer of wealth, while the first approach would not.

CONCLUSION

A government guarantee will radically change the portfolio selection choices made by most participants in a privatized social security system. A guarantee gives a put option to the participant. To maximize the value of the overall investment, a rational participant will seek to maximize the value of this put option by investing in the most volatile investment portfolio available in the privatized social security system, which in turn increases the cost of the government guarantee. When only the contributed principal is guaranteed, the cost of the guarantee is lower for young individuals than older ones. For higher risk portfolios this cost structure reverses when the guaranteed principal is indexed for inflation, and the cost is higher for young individuals than for older ones. From a public policy perspective, our analysis argues neither for the creation of a guaranteed privatized social security program, nor against it. Instead it suggests caution, and that any

explicit or implicit guarantee by the government must be considered carefully in the design of such a system.

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ENDNOTES

1. This is a partial equilibrium analysis, in that we have not considered how an individual's portfolio decisions affect individual saving behavior or labor force participation.
2. In a very recent working paper Feldstein (2005c) uses investment in TIPS and equities to implement a guarantee of real income, and compares this plan with the current system of social security.
3. Various caps have been proposed for individual contributions to the privatized social security accounts. The $1,000 limit was mentioned in the report by the President's Commission to Strengthen Social Security (2002).
4. Alternative specifications for the floor could be based on a more complex social safety net which is available to those with low incomes.
5. The Black-Scholes model does have limitations when used for long-lived options and options on portfolios that contain fixed income instruments, but it is still helpful in providing a useful perspective on the issue of government guarantees.
6. Economists call this kind of change in portfolio selection a "moral hazard" problem.
7. From a macroeconomic perspective, this cost should be compared to the government's existing unfunded social security liability for participants.