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The Value of Social Security Disability Insurance

by

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Foreword

Many analyses of social security estimate the monetary value of retirement benefits by calculating for an individual the difference between the expected present value of lifetime benefits and the expected present value of lifetime contributions. Such analyses, however, have rarely attempted to estimate an important element of social security's value to an individual: the value of benefits provided by disability insurance, or by survivor's insurance in the case of death. By treating social security purely as an investment, these "money's worth" analyses have generally ignored an essential feature of social security: it provides insurance against major life uncertainties.

In an important paper, Geanakoplos, Mitchell, and Zeldes (1999) argue that such "money's worth" measures, unless adjusted for risks such as early death or disability, would understate the value of social security benefits because they ignore the premium individuals would be willing to pay to purchase such insurance protection. If individuals are risk averse, they might be willing to pay a lot for this insurance.

In this paper, Martin Holmer goes beyond the analysis of Geanakoplos, Mitchell, and Zeldes (1999) by developing a methodology for estimating the insurance value of social security Disability Insurance (SSDI), where the insurance value is defined as what an individual is willing to pay for it. Holmer contrasts the insurance value of the SSDI program with its actuarial value, which is what it costs the government to provide the benefits to that individual. He finds that the value of SSDI benefits for an average individual, expressed as a percent of that individuals taxable earnings, is much greater than the actuarial value, often exceeding it by a factor of two or more, even using conservative assumptions about the individual's aversion to risk. The paper shows that the difference between what an average individual is willing to pay for SSDI and what that individual currently pays (via FICA payroll taxes) is larger than the long-term deficit for the whole social security program. In addition, Holmer finds that this result holds under either of the two leading theories of decision-making under risk.

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Executive Summary

Background. Social security is a social insurance program that provides benefits to offset earnings losses associated with disability, death, and retirement. Although this is widely understood, policy analysts typically compare current-law policy with reforms using "money's worth" measures (e.g., the difference between lifetime benefits and lifetime contributions) that ignore the role social security benefits play in cushioning income and consumption levels against earnings declines caused by these events. As a consequence, the value of social security to an individual has been underestimated, and the extent to which the insurance value of the program would change under different kinds of reforms has been ignored.

Geanakoplos, Mitchell, and Zeldes (1999) argue that "money's worth" measures must be adjusted for risk caused by a number of life uncertainties such as disability or early death. They conclude that conventional non-risk-adjusted measures understate the value of social security because they neglect the program's ability to cushion income and consumption levels against earnings declines caused by these uncertainties. Because they ignore the insurance protection features of social security, conventional measures of "money's worth" say nothing about how different reform proposals would alter the insurance value of social security.

Purpose. Our objective in this report is to develop a general method of estimating the insurance value of social security, where *insurance value* is defined as what people are willing to pay for social security benefits. The method must be general enough to use in analysis of the Old-Age Insurance, Survivors Insurance, and Disability Insurance (DI) programs. And it must be flexible enough to handle different sources of lifetime uncertainties, including disability, death, and earnings uncertainty. An additional objective of the report is to use this method to estimate the insurance value of DI benefits as well as their *actuarial value*, which is the cost of providing the benefits.

Methods. Our general method combines the use of Monte Carlo simulation to represent risks that cause uncertainty in lifetime earnings and benefits received, and theories of choice under risk to calculate the insurance value of benefits, which is expressed as a percent of taxable earnings.

The Monte Carlo simulation of individual lifetimes is conducted with the SSASIM micro model of cohort individuals (Holmer 2001) using new research findings from the Social Security Administration's Office of the Chief Actuary on average transition rates on to and off of the DI program by age and gender (Zayatz 1999).

The insurance value of the simulated DI benefits is calculated using two leading theories of choice under risk: expected utility theory (assuming different degrees of risk aversion) and cumulative prospect theory (Tversky and Kahneman 1992). We use cumulative prospect theory because there is a substantial empirical literature showing that expected utility theory often fails to predict accurately how people make decisions among risky prospects (Starmer 2000). We show that our calculation method implies that if an individual is not averse to risk, then the insurance value for that individual's benefits equals their actuarial value. In other words, individuals who are concerned only about their average prospects, and not the consequences of life outcomes that are better or worse than average, will value the benefits just like an insurance company would calculate the expected cost of providing benefits to a large group of people.

Findings. For men and women who are risk averse, have average chances of becoming disabled, and have average earnings for people their age and gender, we find that the insurance value of DI benefits (i.e., the amount they are willing to pay) substantially exceeds their actuarial value (i.e., the cost of providing the benefits). This result is true for a range of assumptions about the extent of their aversion to risk. The size of the difference is larger for single individuals than for married individuals considered as a couple, because income sharing within the couple noticeably cushions income against the earnings reductions caused by disability.

These results imply that conventional estimates of the insurance value of DI benefits are understated by a large amount. Of the cases we have considered, the smallest understatement is for the couple with the lowest level of risk aversion. In this case, when we recognize the insurance protection provided by the DI program rather than ignore it as the actuarial value calculations do, the net insurance value — the insurance value minus the payroll tax rate — rises 0.3 percentage points from +0.2 to +0.5 percent of taxable earnings. In this case with the smallest understatement, the net insurance value more than doubles when we recognize the insurance protection provided by the DI program. In other cases that involve single individuals or higher assumed degrees of risk aversion, the difference between the insurance value and the actuarial value of DI benefits is much larger. In these cases, the insurance value is typically at least twice the actuarial value of DI benefits.

Conclusions. Our results indicate that use of conventional measures of "money's worth" leads to a substantial underestimation of the value of insurance protection provided by the DI program. The findings in this report suggest interesting methodological extensions and the importance of applying this method of estimating insurance value to other parts of the social security program and to other types of lifetime risk.

Contents

Introduction

Social security is a social insurance program that provides benefits to offset earnings losses associated with disability, death, and retirement. Although this is widely understood, policy analysts typically compare current-law policy with reforms using "money's worth" measures (e.g., the difference between lifetime benefits and lifetime contributions) that ignore the role social security benefits play in cushioning income and consumption levels against earnings declines caused by these events. As a consequence, the value of social security to an individual has been underestimated, and the extent to which the insurance value of the program would change under different kinds of reforms has been ignored.

This point has been made by Geanakoplos, Mitchell, and Zeldes (1999, pp. 125), who conclude their theoretical investigation into the validity of conventional (i.e., non-risk-adjusted) "money's worth" measures by observing:

> ... There are several reasons [why] the non-risk-adjusted approach to money's worth estimates for the current social security system are too low, arising from the failure of the [theoretical] assumption[s] described above. Such failures arise because many of the risks that households face — uncertainty about earnings, length of life, disability, and health expenses — may not be fully insurable or hedgeable in private markets. ...
>
> ... The non-risk-adjusted approach to money's worth calculations, therefore, tends to understate the benefits of social security because it calculates benefits at actuarial probabilities, neglecting the insurance premium that participants would be willing to pay beyond those expected benefits [in order] to receive the social security stream of benefits.

In other words, actuarial calculations over a large population neglect the risk premium that an individual would be willing to pay for insurance.

In this report, we define insurance value as the percent of taxable earnings that an individual would be willing to pay to avoid the elimination of social insurance benefits. This differs from the concept of actuarial value, the cost of providing benefits to the individual, which is defined as the mathematical expected value of benefits ("expected benefits" in the quote above). The difference between the insurance value of benefits and the actuarial value of benefits arises because a risk-averse individual cannot average out life uncertainties in the same way an insurance company can average claim experiences over a broad group of people.

We develop a general method of estimating the insurance value of social security, apply it to the Disability Insurance (DI) program, and compare the resulting insurance values with conventional actuarial values. These estimates indicate that the insurance value of social security DI benefits substantially exceeds the actuarial value of those benefits. *Under a range of plausible assumptions, the insurance value is at least twice the actuarial value of DI benefits.*

The estimation method combines the use of Monte Carlo simulation to represent risks that cause uncertainty in lifetime earnings and benefits received, and theories of choice under risk to calculate the insurance value of benefits.

The Monte Carlo simulation of individual lifetimes is conducted with the SSASIM micro model of cohort individuals (Holmer 2001) using new research findings on average transition rates onto and off of the DI program by age and gender. DI benefits, including auxiliary benefits for spouses and children of disabled workers, are calculated for current-law policies. The Monte Carlo simulation produces a probability distribution for the present value of lifetime earnings and the present value of lifetime DI benefits for each individual. This distribution represents the uncertainty facing an individual, with each value in the distribution representing a different possible life outcome for the individual. Because DI benefits are received when disability reduces earnings, they reduce the variability of net income across possible life outcomes.

The insurance value of the simulated DI benefits is calculated using two leading theories of choice under risk: expected utility theory (assuming different degrees of risk aversion) and cumulative prospect theory (Tversky and Kahneman 1992). We use cumulative prospect theory because there is a substantial empirical literature showing that expected utility theory often fails to predict accurately how people make decisions among risky prospects (Starmer 2000). Using these different theories, we estimate both the insurance value and actuarial value of DI benefits. We show that if an individual is not averse to risk, then the insurance value of that individual's benefits equals their actuarial value, which means that conventional "money's worth" measures would be correct. But if an individual is at all risk averse, conventional measures are too low, with the degree of understatement increasing with the individual's degree of risk aversion.

Simulation of Cohort Individuals

We describe briefly our simulation methods and assumptions in this section, and then present results on the lifetime probability of DI receipt and the average level of DI benefits for individuals with average disability chances.

Methods and Assumptions. We simulate distributions of possible lifetime outcomes for individuals born in 1978. Individuals are considered as unmarried, married, and as a couple. The individuals are assumed to start working in 2000 at age 22, to engage in continuous full-time work when not disabled, to not work at all when disabled, and to retire at age 65 in 2043 when the normal retirement age will be 67. These highly-stylized lifetime assumptions are similar to those made by the Social Security Administration's Office of the Chief Actuary (Advisory Council 1997, p. 175, for example). We assume married individuals plan to have a first child at age 25 and a second child at age 30. Married individuals are assumed to never divorce or remarry.

Our analysis focuses on a man and a woman who are assumed to have average earnings levels, average mortality rates, and average disability chances. We use the following assumptions in the SSASIM micro model of cohort individuals (Holmer 2001) to generate distributions of the present value of lifetime earnings and present value of lifetime DI benefits, which are based on 10,000 Monte Carlo replications of each individual's life.

Assumed Earnings Profiles. We assume that these two individuals receive, when they work, the average earnings of everyone who is their age and gender. This differs from the "average" earner often used in social security policy analysis, which assumes a flat aggregate age-earnings profile that is identical for men and women (Advisory Council 1997, p. 176). Instead, we use relative values of average earnings for each age and gender, tabulated from Current Population Survey annual earnings data, to specify more realistic aggregate age-earnings profiles for men and women. These aggregate profiles show that, on average, earnings (measured relative to the economy-wide average) generally rise with age until just before retirement, and that on average men earn more than women at the same age (Toder et al. 1999, p. 9, for example). The profiles' age-related earnings increases over a career are in addition to earnings increases caused by aggregate economic growth, which is assumed to occur at the pace implied by the intermediate-cost assumptions made in the Trustees' Report (2001).

Recent tabulations of longitudinal earnings histories from Social Security Administration administrative records by Bosworth, Burtless, and Steuerle (1999) illustrate the wide variability in the population around this average rising age-earnings profile. Their tabulations indicate that declining, slumping, and other irregular lifetime earnings profiles are caused in part by periods of time spent out of the paid labor force, including periods of disability. This substantial variability in earnings profiles, even among those whose average lifetime earnings are similar, highlights the importance of earnings risk. In this report, we incorporate the risk of disability and pre-retirement death, both of which cause irregular lifetime earnings profiles. But we analyze the insurance value of DI benefits only, ignoring benefits received from the survivors insurance program.

Assumed Mortality Rates. All the individuals considered in our analysis are assumed to experience throughout their lives age- and gender-specific average mortality rates observed in 1992. In other words, for this analysis we assume that all individuals have average mortality rates (unless they are disabled) and that these average rates do not decline in the future. Our simulations simply project the lifetime consequences of current mortality rates, just as the conventional life expectancy statistic uses current-year mortality rates to compute the average age of death for those born in the current year.

Assumed Disability Chances. Age- and gender-specific rates of movement on to and off of the DI program are drawn from a recent study published by the Social Security Administration's Office of the Chief Actuary. Age- and gender-specific incidence rates (i.e., probabilities of first becoming a DI beneficiary) are based on 1998 data (Zayatz 1999, Table 4). Age- and gender-specific recovery rates (i.e., probabilities of leaving DI for reasons other than death or conversion to the Old-Age Insurance program) are based on data for the 1991–95 period (Zayatz 1999, Table 8). And the ratio of mortality rates between DI beneficiaries and the whole population are calculated using DI mortality rates for the 1991–95 period (Zayatz 1999, Table 7) and population-wide mortality rates for 1992. The assumed transition rates off the program imply that the average simulated time on the DI program agrees closely with the estimates of expected time on the program reported by Zayatz (1999, Table 13). Just as for mortality rates, our analysis determines the lifetime implications of these 1990s disability transition rates by projecting them unchanged into the future.

All rates drawn from this actuarial study are average rates for everyone in each age-gender group. We use these average rates to characterize the transition probabilities on to and off of the DI program for the two average earners defined above. In other words, our average earners are assumed to have average disability chances.

Benefit Policy Parameters. Once an individual is simulated to apply for DI benefits, SSASIM's micro model determines whether that individual's earnings history is sufficient to confer disability-insured status, and if so, calculates the disabled worker's benefit and auxiliary benefits for the disabled worker's spouse and children. SSASIM generates annual DI benefits, using current-law benefit policy parameters to calculate the basic and auxiliary benefits and to apply the maximum family benefit restrictions and earnings test.

Assumed Discount Rate. In each possible lifetime, annual earnings and annual DI benefits are discounted to present values at age 65 that are expressed in 1998 dollars. The nominal interest rate and inflation rate in each possible lifetime is assumed to be 6.3 percent and 3.3 percent, respectively, as in the intermediate-cost assumptions of the Trustees' Report (2001). Using this nominal interest rate as the discount rate in each possible lifetime permits us to represent risks with a distribution of outcomes and then adjust that distribution using theories of choice under risk. Before explaining how those risk-adjustment calculations produce insurance values, we present selected simulation results for our average individuals.

Lifetime DI Experience for Average Individuals. We show results on the lifetime probability of DI receipt and the level of DI benefits in Table 1 on the following page.

The top panel of Table 1 presents results assuming our average individuals are never married, which means these are disabled worker estimates. The 21.6 and 21.7 percent lifetime probabilities of DI benefit receipt for the woman and man, respectively, may be compared with MINT-model estimates of 16.5 and 20.9 percent for all women and all men, respectively, in the 1931–1960 birth cohorts (Toder et al. 1999, pp. 26–27). The difference in the two estimates for men is less than one percentage point. In other work not reported here, we find that the larger difference for women is caused primarily by the difference in employment rates between women in these cohorts and our continuously-working woman, who never fails to be disability insured. Turning to our level of benefits results, the higher mean lifetime benefits for the man ($229,000) reflect his higher lifetime earnings.

Table 1: ***Estimates of Lifetime Probability of DI Receipt and Level of DI Benefits Received over a Lifetime for Individuals with Average Disability Chances and Average Earnings.*** *See text for detailed assumptions (pages 3–5). Lifetime probability of DI receipt calculated using 10,000 simulated lifetimes. Mean present value of benefits calculated using only lifetimes in which DI benefits are received.*

Individual or Couple	Percentage Probability of DI Receipt	Mean PV of Lifetime DI Benefits ($ million) (including only receipts)
Single Woman	21.6	0.185
Single Man	21.7	0.229
Married Woman	31.3	0.137
Married Man	30.5	0.180
Couple	38.1	0.256

The middle panel of Table 1 shows results for these same two individuals when they are married and eligible for auxiliary benefits. The receipt of spousal benefits, which occurs when the individual's spouse becomes disabled, increases lifetime probabilities of DI receipt (relative to when the individual is single) and decreases average benefits (because spousal benefits are smaller than disabled worker benefits).

The bottom panel of Table 1 shows the lifetime probability of DI receipt and average benefits for the couple consisting of our average man and average woman. The lifetime probability for the couple is not quite as high as the sum of those for the single individuals because there is a small chance of both individuals becoming disabled during their lifetimes.

The expected present value of lifetime DI benefits can be calculated from these results by multiplying an individual's probability of DI receipt by that person's mean present value of positive DI benefits. Such a calculation produces estimates of the expected present value of DI benefits that are roughly consistent with those calculated in an earlier study of the actuarial value of DI benefits (Bakija and Steuerle 1995).

In sum, our average individuals have about a one-in-five chance of receiving disabled worker benefits in their lifetimes, and our average couple has nearly a two-in-five chance of at least one partner receiving DI benefits.

Calculation of Insurance Value

In this section of the report, we define insurance value using two different theories of choice under risk, work through example calculations of insurance value, and present estimates of the insurance value and actuarial value of DI benefits for our two average individuals under various assumptions about their aversion to risk.

Methods and Examples. As discussed above, SSASIM uses Monte Carlo methods to generate a distribution of the present value of lifetime earnings and the present value of lifetime DI benefits for each individual. This simulated distribution represents the uncertainty facing an individual, with each value in the distribution representing a different possible life outcome for the individual.

The *actuarial value* of DI benefits is the cost of providing those benefits, which is defined as the expected present value of lifetime DI benefits, where the expectation is calculated over this simulated distribution of potential life outcomes for an individual. Often the actuarial value is expressed in monetary units (Steuerle and Bakija 1994, for example), but here we express it as a percent of social security taxable earnings.

The *insurance value* is defined as the maximum percent of taxable earnings that an individual would be willing to pay to avoid the elimination of the DI program. This means the insurance value represents the DI payroll tax rate at which an individual would be indifferent between keeping and eliminating DI coverage. The insurance value may be viewed as a risk-adjusted actuarial value.

As made clear by Geanakoplos, Mitchell, and Zeldes (1999), we must assume something about an individual's attitudes towards uncertainty in order to adjust the actuarial value of benefits for risk. Here we do that using a variety of assumptions concerning an individual's attitudes towards risk, which are derived from numerous experimental and non-experimental studies of individual behavior. We calculate the insurance value using both expected utility theory (EUT) and cumulative prospect theory (CPT), the two most widely recognized theories of choice under risk.

In both cases, we use distributions of the present value of an individual's lifetime earnings (denoted by E), the present value of lifetime DI benefits (denoted by B), and the present value of lifetime DI payroll taxes (denoted by T). The E distribution represents the net income distribution when there is no DI program, while the $E+B-T$ distribution represents the net income distribution when there is a DI program.

See Figure 1 on the next page for an example of a simulated E distribution. This figure shows that in nearly sixty percent of his possible lifetimes (horizontal portion of the line), our average man will live to retirement age without becoming disabled. In all those cases, his lifetime earnings stream is the same (because of the steady working assumption) and the present values of those identical earnings streams are all the same (because of the assumption of a constant interest rate used to discount earnings). The level of that horizontal portion of the line in Figure 1 on the facing page is \$3.3603 million dollars. In the other forty percent of possible lifetimes, our average man experiences either disability (21.7%) or death before retirement, events that cause declines in his subsequent earnings, and hence, lower the present value of lifetime earnings. We can see in Figure 1 that some of these reductions are modest, while others are quite substantial. For example, in about six percent of possible lifetimes, the present value of lifetime earnings falls below \$1.5 million dollars, which is less than half the level he experiences when he does not become disabled or die before retirement.

Figure 2 on page 10 shows for the same average man the simulated $T-B$ distribution, which represents the *gain* in net income (relative to Figure 1 on the facing page) from eliminating the DI program ($E-(E+B-T)$). We discuss the nature of this distribution below as part of our example calculations.

When using *expected utility theory*, we calculate the psychological value (or overall desirability) of an individual's earnings distribution (E) and then find the payroll tax rate that produces a net income distribution ($E+B-T$) that has exactly the same psychological value. If t_e denotes the tax rate that makes the $E+B-T_e$ distribution have a psychological value equal to that of the E distribution, then t_e is the insurance value of current-law DI benefits (as represented by the B distribution). The Appendix beginning on page 17 contains the technical definition of psychological value and mathematical details of its calculation.

To measure the psychological value of a risky distribution, we calculate the level of a certain distribution that has the same overall desirability to an individual as does the risky distribution. A certain distribution is one that has no risk, and therefore, would be represented in either Figure 1 or Figure 2 as a horizontal line. In the technical literature and in the Appendix, the psychological value is called the certainty-equivalent value of a risky

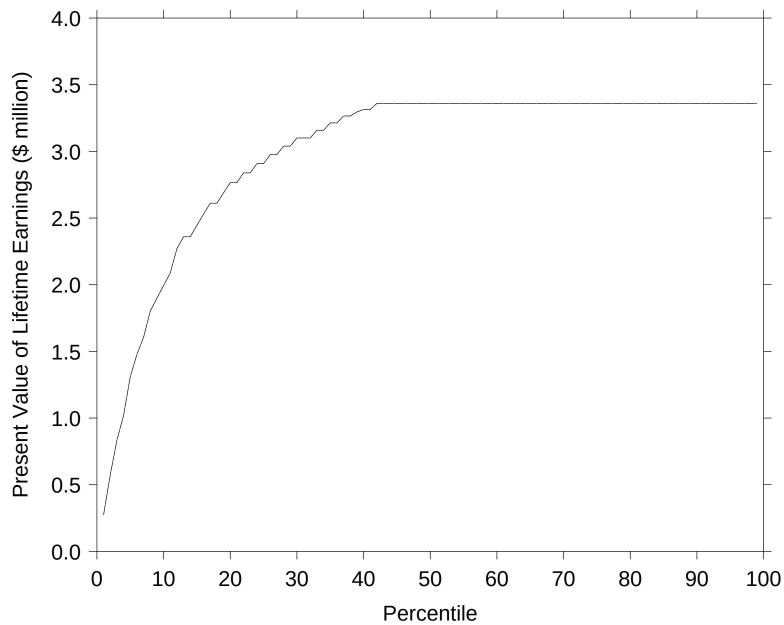

Figure 1: ***Distribution of Present Value of Lifetime Earnings for Average Man.*** *Present value at age 65 expressed in 1998 dollars.*

distribution. We discuss this concept further in the example calculations below.

We estimate the insurance value of DI benefits using expected utility theory and several assumed values of the degree of risk aversion, which is denoted by β. We assume β values that range from as high as 2.7 to as low as 0.0, which means no aversion to risk. This range is on the low side of commonly assumed values. For example, Cochrane (2001, p. 457) states that "it has been traditional to use risk aversion numbers [β] of 1 to 5 or so." And recent empirical work suggests that people may be even more risk averse than this. For reviews of this work see Campbell, Lo, and MacKinlay (1997, Chapter 8) and Cochrane (2001, Chapter 21). We show in the Appendix that when an individual is not averse to risk (i.e., β=0), the insurance value equals the actuarial value.

Using our average man as an example, we show how to calculate actuarial value and insurance value using expected utility theory. The mean and standard deviation of the earnings distribution (E) shown in Figure 1 are 2.9885 million and 0.70 million dollars, respectively. Using current-law bene-

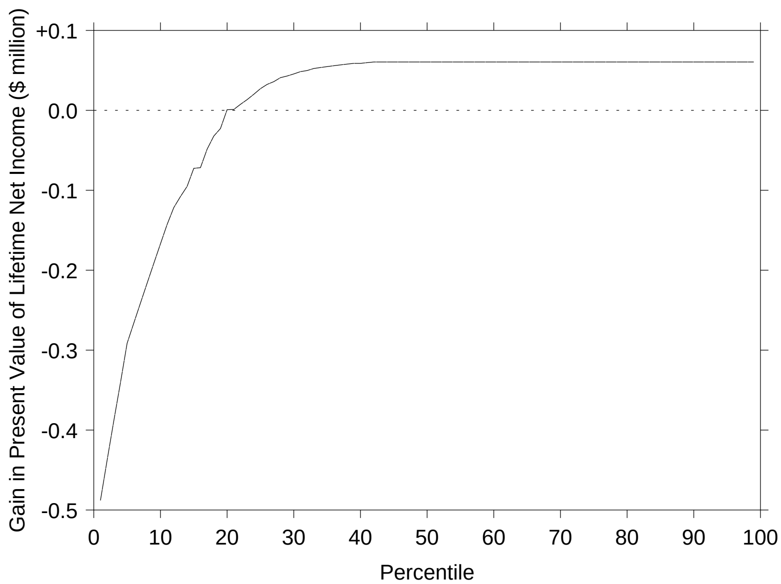

Figure 2: ***Distribution of Gain in Present Value of Lifetime Income from Elimination of DI Benefits and Taxes for Unmarried Average Man.*** *Gain defined as present value of current-law DI taxes (at 1.8 percent rate) minus present value of current-law DI benefits. Present values at age 65 expressed in 1998 dollars.*

fit policy for a single individual and the current-law tax rate of 1.80 percent, the corresponding mean and standard deviation of the net income distribution $(E + B - T)$, which is not shown, are 2.9844 million and 0.64 million dollars, respectively. The lower variance (0.64 with the DI program versus 0.70 without it) shows the income cushioning effect of the DI program. The lower mean for the net income distribution (2.9844 with the program and 2.9885 without) shows that the actuarial value of benefits (the mean of the B distribution) is less than the actuarial value of taxes (the mean of the T distribution) for this unmarried man. If the tax rate were lowered to 1.66 percent, the mean of the net income distribution would be 2.9886 million dollars. This shows that the actuarial value of DI benefits for this individual is about 1.66 percent of taxable earnings, slightly lower than the current 1.80 percent DI payroll tax rate.

Continuing our example, we show how the insurance value is calculated for this man under the assumption that he is somewhat averse to risk (EUT $\beta =$

1.8). The psychological value of the earnings distribution is 1.9641 million dollars. In visual terms, this means that this individual would be indifferent between the risky earnings distribution shown in Figure 1 on page 9 and a certain level of earnings equal to 1.9641 million dollars, which would be represented as a horizontal line with height 1.9641 million dollars.

The psychological value of the net income distribution, which is not shown, is 2.0286 million dollars when using the current-law tax rate of 1.80 percent. Given his assumed attitudes towards risk, the man prefers the net income distribution $(E + B - T)$ to the earnings distribution (E). How high could the tax rate go before this preference is reversed? If the tax rate were increased to 5.50 percent, the psychological value of the net income distribution would fall to 1.9642 million dollars, while 5.51 percent implies a 1.9640 million dollar psychological value. These EUT calculations indicate that the insurance value of DI benefits for this man is close to 5.50 percent of taxable earnings. This means that he would be willing to pay 5.50 percent of his taxable earnings every year to avoid the elimination of the DI program. It is worth noting that in this calculation, the rate he would be willing to pay is more than three times what he currently pays. Now, we turn to the calculation of insurance value using a different representation of attitudes toward risk.

When using *cumulative prospect theory*, we assume a mathematical representation of the theory that is based on numerous empirical studies of individual decision-making under uncertainty (Tversky and Kahneman 1992). See the Appendix on page 17 for mathematical details. When assuming individual attitudes toward risk are represented by cumulative prospect theory, the insurance value is the DI payroll tax rate t_c that produces a zero psychological value (or certainty-equivalent) for the gain in net income distribution $(E - (E + B - T_c))$ from eliminating the DI program.

Returning to our example using the average (unmarried) man, the gain distribution shown in Figure 2 on the preceding page has a mean of 0.0041 million dollars and a standard deviation of 0.122 million dollars. The positive mean shows that on average this man gains from the elimination of the DI program. In other words, the actuarial value of benefits for this man is less than the DI payroll tax rate. The relatively large gain variance reflects the shape of the gain distribution. He experiences a modest gain (the eliminated taxes) when he does not become disabled, which occurs in about eighty percent of his possible lifetimes, and experiences an often sizeable loss when he does become disabled (and does not receive DI benefits), which occurs in the other twenty percent of possible lifetimes. When using cumulative prospect theory, the psychological value of this gain distribution is –0.0401 million dollars. This means that the man is indifferent between the risky gain distribution shown in Figure 2 and a certain distribution represented by a horizontal line (not shown) at the –0.0401 million dollar level.

So, in this example, current-law policy is preferred by this man to the elimination of the DI program at the current tax rate. This is because the psychological value of the gains from no policy change (zero dollars, by definition, because we consider current-law policy as the reference point when using cumulative prospect theory) is greater than the psychological value of gains from elimination (–0.0401 million dollars). How high would the tax rate have to be to make this man cease to prefer current-law DI benefit policy to eliminating the DI program? Trying numerous values, we find that if the tax rate were 5.59 percent, the psychological value of the gain-from-elimination distribution would be –0.0001, while 5.60 percent implies 0.0000, and 5.61 percent implies a psychological value of the gain distribution of +0.0001 million dollars. These CPT calculations indicate that the insurance value of DI benefits for this man is 5.60 percent.

We calculate the insurance value of DI benefits using cumulative prospect theory to provide some sense of the appropriate range of assumed values for the expected utility theory risk aversion parameter β. This is necessary because empirical studies of individual behavior have produced a broad range of estimates for β. Recent work, especially concerning the "equity premium puzzle" presented by the large gap in average returns on corporate equities versus government bonds, suggests that individuals must have relatively high values of β, certainly much higher than some earlier studies suggest (Campbell, Lo, and MacKinlay 1997, Chapter 8, for example).

Another reason for using cumulative prospect theory is that there is a substantial empirical literature showing that expected utility theory often fails to predict accurately how people make decisions among risky prospects (Starmer 2000, for a recent review). For a direct comparison of the predictive power of these two theories in a situation in which people are choosing among health insurance plans with different cost-sharing provisions and premium levels, see Marquis and Holmer (1996), who find a version of prospect theory predicts people's choices of health insurance plans significantly better than expected utility theory.

Table 2: ***Estimates of Value of Disability Insurance for Individuals with Average Disability Chances and Average Earnings.*** *Value estimates expressed as a percent of taxable earnings. See text for detailed assumptions (pages 3–5) and value calculation methods (page 7).*

Individual or Couple	Actuarial Value (β=0.0)	Insurance Value EUT (β=0.9)	EUT (β=1.8)	EUT (β=2.7)	CPT
Single Woman	2.1	3.1	5.8	—	7.2
Single Man	1.7	2.6	5.5	—	5.6
Married Woman	2.2	3.4	6.3	—	7.9
Married Man	1.8	2.9	6.0	—	6.3
Couple	2.0	2.3	2.9	4.8	5.2

DI Value for Average Individuals. Using the recent research findings on average DI transition rates described above as behavioral parameters in simulations performed by the SSASIM micro model of cohort individuals, we have produced the estimates of insurance value shown in Table 2.

The top panel of Table 2 contains actuarial value and insurance value estimates for our two individuals when they are single and, therefore, do not receive auxiliary disability benefits. The actuarial value of DI benefits for the average woman is 2.1 percent of her taxable earnings, while the actuarial value for the average man is 1.7 percent of his higher taxable earnings. The insurance value of DI benefits is much higher than the actuarial value for these single individuals.

Looking now at the middle panel of Table 2, we see that the actuarial and insurance value estimates are somewhat higher for our two individuals when we consider them as married, and hence, eligible for spousal and child DI benefits. The actuarial value estimates for the average woman and man are now 2.2 and 1.8 percent, respectively. And the insurance values are much higher, even at low levels of risk aversion.

Finally, consider the bottom panel of Table 2, which shows the estimates for the married individuals considered as a couple. The actuarial value of full DI benefits for the average couple is 2.0 percent of their combined taxable earnings. By way of comparison, the DI payroll tax rate is now 1.8 percent of taxable earnings, the income taxation of benefits adds another 0.1 percent, and an additional 0.3 percent of taxable earnings will be required to achieve program solvency over the next seventy-five years (Trustees' Report 2001, intermediate-cost assumptions). In other words, the actuarial value of aggregate DI benefits is projected to be about 2.2 percent of aggregate taxable earnings.

The insurance values for the couple are dramatically lower than those for the married individuals considered alone. This difference illustrates the risk-reducing effects of income sharing between the two married individuals. This occurs because both members of the couple are unlikely to experience earnings reductions associated with disability at the same time. Despite a considerable degree of income cushioning within the couple, the insurance value of DI benefits is considerably higher than the actuarial value at all but the lowest degrees of risk aversion.

Analytical Extensions. In future work, we plan to extend this insurance value analysis in several directions. From a methodological perspective, we intend to adopt an approach that uses the discounted value of the utility of consumption (rather than the present value of lifetime net income) as the outcome measure. This would involve using the same consumption-based model used in financial economics to value assets with contingent payoffs (Cochrane 2001). This methodological extension will involve simulating private savings, which can also cushion consumption against earnings losses. This consumption-based method of calculating insurance value may produce different estimates than reported here. Recognizing the timing of consumption (which the current lifetime present value analysis ignores) is likely to increase insurance value, while recognizing the possibility of saving is likely to decrease insurance values.

In the context of the DI program, we plan to extend the analysis to focus on how disability chances vary for those with higher or lower than average lifetime earnings levels. Such an analysis will allow us to estimate the net insurance value of the DI program for a wider range of individuals. And more interestingly, we will then be able to estimate the insurance value of DI benefits when individuals are not certain of their lifetime disability chances.

More broadly, we plan to apply the consumption-based method of estimating insurance value to other types of social security benefits, and to sources of lifetime risk other than disability.

Conclusion

In the introduction, we quote Geanakoplos, Mitchell, and Zeldes (1999) on the need to risk adjust social security "money's worth" measures, and on the downward bias in measures that neglect the income cushioning effects of social security. In this report, we develop a general method for producing a risk-adjusted "money's worth" measure that recognizes the income cushioning effects of social security, and apply that method to the social security Disability Insurance program. Our results show the magnitude of the downward bias in conventional (i.e., non-risk-adjusted) "money's worth" measures for the DI program.

In an earlier study of the actuarial value of DI benefits, Bakija and Steuerle (1995, pp. 12–13) explain the conventional view as follows:

> In this analysis, we estimate and compare the present actuarial value at age 65 of lifetime SSDI taxes and benefits for a set of representative workers from the cohort born in 1965. ...
>
> The lifetime benefit amount represents the cash value of the insurance protection provided by the SSDI system and can be interpreted as the lump sum that would have to be paid at age 65 to provide an equal value of benefit in lieu of SSDI coverage.

But this is true only if individuals have no aversion to risk. If they are risk averse, the "insurance protection" of DI benefits causes the insurance value of benefits to be higher than their actuarial value.

Returning to the unmarried man used in our examples above, the actuarial value of his DI benefits is 1.66 percent of his taxable earnings, his DI payroll tax rate is 1.80 percent, and the insurance value of his DI benefits is 5.50 percent of taxable earnings (when expected utility theory with a relative degree of risk aversion of 1.8 is assumed to represent his attitudes towards risk). The conventional view would observe that, because the present value of expected benefits is less than the present value of taxes, he experiences a negative net present value, a present value ratio that is less than one, and an internal rate of return on his tax contributions that is below the market interest rate. Using our units of measure, the conventional view would be that his net insurance value is –0.14 percent of taxable earnings (1.66 – 1.80). All this is true only if we are willing to maintain the extreme assumption that he is not averse to risk. But if he is averse to risk in the manner assumed above, then the net insurance value of the DI program is +3.70 percent of taxable earnings (5.50 – 1.80). The magnitude of the downward bias in the conventional measure of value is enormous in this case because he is willing to pay more than three times the current tax rate.

Looking at the broader range of cases in Table 2 on page 13, we see that the smallest downward bias is for the couple with the lowest level of risk aversion ($\beta = 0.9$). In this case, when we recognize the insurance protection provided by the DI program rather than ignore it in the actuarial value calculations, the net insurance value rises from +0.2 to +0.5 percent of taxable earnings. In this case with the smallest downward bias, the net insurance value more than doubles when we recognize the insurance protection provided by the DI program.

Our results indicate that using conventional measures of "money's worth" leads to a substantial underestimation of the value of insurance protection provided by the DI program. For men and women who are risk averse, have average chances of becoming disabled, and have average earnings for people their age and gender, we find that the insurance value of DI benefits (i.e., the amount they are willing to pay) substantially exceeds the actuarial value of DI benefits (i.e., the cost of providing the benefits), often by a factor of two or more. This result is true for a range of assumptions about the extent of their aversion to risk. The size of the difference is larger for single individuals than for married individuals considered as a couple, because income sharing within the couple noticeably cushions income against the earnings reductions caused by disability.

Under a wide range of assumptions about risk aversion, the insurance value exceeds the actuarial value of DI benefits by an amount that is larger than the long-run funding deficit in the whole social security program, which is currently estimated at somewhat less than 1.9 percent of taxable earnings (Trustees' Report 2001, p. 56 intermediate-cost projection).

The magnitude of these estimates of the insurance value of DI benefits suggests that reforms that reduce traditional social security benefits in order to carve out room for an individual account may have a difficulty maintaining the insurance value of DI benefits. In fact, a recent study by the General Accounting Office (GAO 2001) shows that a number of Congressional proposals for introducing individual accounts adversely affect social security beneficiaries who become disabled before they retire.

Appendix: Theories of Choice Under Risk

We describe here the mathematical details of the certainty-equivalent (or "psychological value") calculations used to compute insurance value. We show how either expected utility theory or cumulative prospect theory can be used in the calculations. In this report, we define the outcome as the present value of lifetime net income: earnings plus DI benefits minus DI taxes in the current-law policy regime, and just earnings in the other DI-elimination policy regime. In this appendix, we use the term "scenario" to refer to a Monte Carlo replication.

See Starmer (2000) for a discussion of differences between expected utility theory, cumulative prospect theory, and other non-expected utility theories of choice under risk.

Expected Utility Theory. When expected utility theory is used to calculate the certainty-equivalent outcome of an outcome distribution, a power utility function is commonly assumed. This kind of utility function has the form

$$u(x) = \begin{cases} \frac{1}{1-\beta} x^{1-\beta} & \text{if } \beta \neq 1 \text{ and } x > 0 \\ log(x) & \text{if } \beta = 1 \text{ and } x > 0 \end{cases}$$

where β denotes the degree of relative risk aversion (with zero implying no aversion to risk or "risk neutrality") and x the value of the outcome. If the outcome distribution is represented by $X = \{x_1, \ldots, x_n; p_1, \ldots, p_n\}$ where x_i denotes the value of the outcome in scenario i and p_i the probability of that scenario, then the expected utility of an outcome distribution X is simply

$$EU(X) = \sum_{i=1}^{n} p_i u(x_i).$$

And the certainty-equivalent value for an outcome distribution X, denoted by x^*, is the value that solves the equation

$$u(x^*) = EU(X).$$

Given the adoption of a power utility function, the only additional assumption that needs to be made is the value of the relative risk aversion parameter β.

The assumption $\beta = 0$ implies no aversion to risk. In this case, $u(x) = x$, and therefore, the certainty-equivalent x^* equals the mean of the X outcome distribution, which is the actuarial value of the outcome.

Cumulative Prospect Theory. If cumulative prospect theory is used to calculate the certainty-equivalent outcome of an outcome distribution, a different set of calculations is required (Tversky and Kahneman 1992, Kahneman and Tversky 1979).

The major features of cumulative prospect theory are described in a summary paragraph by Tversky and Kahneman (1992, p. 316):

> Theories of choice under uncertainty commonly specify 1) objects of choice, 2) a valuation rule, and 3) the characteristics of the functions that map uncertain events and possible outcomes into their subjective counterparts. In standard applications of expected utility theory, the objects of choice are probability distributions over wealth, the valuation rule is expected utility, and utility is a concave function of wealth. The empirical evidence reported here and elsewhere requires major revisions of all three elements. We have proposed an alternative descriptive theory in which 1) the objects of choice are prospects framed in terms of gains and losses, 2) the valuation rule is a two-part cumulative functional, and 3) the value function is S-shaped and weighting functions are inverse S-shaped. The experimental findings confirmed the qualitative properties of these scales, which can be approximated by a (two-part) power value function and by identical weighting functions for gains and losses.

The first distinctive feature of cumulative prospect theory is that it deals with gain, not outcome, distributions. Let $X = \{x_1, \ldots, x_n; p_1, \ldots, p_n\}$ and $Y = \{y_1, \ldots, y_n; p_1, \ldots, p_n\}$ denote the probability distributions of an outcome for two policies simulated over the same Monte Carlo scenarios (indexed by i). The gain distribution for the policy that generates outcome distribution Y, relative to the reference policy that generates outcome distribution X, is defined as $G = \{g_1, \ldots, g_n; p_1, \ldots, p_n\}$ where $g_i = y_i - x_i$. Following this scenario-by-scenario gain calculation, the elements of this gain distribution G are sorted into ascending order with the smallest gain (which is often a large loss) being labeled with $i = 1$ and the largest gain being labeled with $i = n$.

The second distinctive feature of cumulative prospect theory is that decision weights, rather than probabilities, are used in the assessment of gain distributions. The decision weight associated with gain g_i, which is denoted as π_i, is defined as

$$\pi_i = \begin{cases} w^-(p_1) & \text{for } i = 1 \\ w^-(p_1 + \cdots + p_i) - w^-(p_1 + \cdots + p_{i-1}) & \text{for } i > 1 \text{ and } g_i < 0 \\ w^+(p_i + \cdots + p_n) - w^+(p_{i+1} + \cdots + p_n) & \text{for } i < n \text{ and } g_i \geq 0 \\ w^+(p_n) & \text{for } i = n \end{cases}$$

where the two weighting functions w^- and w^+ have the same form, but possibly different parameter values (Tversky and Kahneman 1992, p. 301). The mathematical form of the common weighting function w is

$$w(p) = \frac{p^\gamma}{(p^\gamma + (1-p)^\gamma)^{1/\gamma}}$$

where the γ value differs slightly between the w^+ function for gains and the w^- function for losses. Based on results from experimental research, Tversky and Kahneman (1992, pp. 309–312) recommend a γ value of 0.61 for the w^+ function and 0.69 for the w^- function.

This weighting procedure reflects the empirical phenomenon that people overweigh small probabilities and underweigh high probabilities. "Overweighting of small probabilities contributes to the popularity of both lotteries and insurance. Underweighting of high probabilities contributes both to the prevalence of risk aversion in choices between probable gains and sure things, and to the prevalence of risk seeking in choices between probable and sure losses." (Tversky and Kahneman 1992, p. 316)

The third distinctive feature of cumulative prospect theory is the "S-shaped" value function used to evaluate gains and losses. Following Tversky and Kahneman (1992, pp. 309–312) the value function has the form

$$v(g) = \begin{cases} g^\alpha & \text{if } g \geq 0 \\ -\lambda(-g)^\alpha & \text{if } g < 0 \end{cases}$$

where g denotes a gain and α and λ are taken to be 0.88 and 2.25, respectively. A λ value greater than one represents a basic empirical phenomenon of choice under uncertainty: loss aversion, that "losses loom larger than gains" (Tversky and Kahneman 1992, p. 298).

Cumulative prospect theory could be described as a theory of weighted value maximization (rather than expected utility maximization), where the decision weights differ from probabilities and value is measured in terms of gains and losses. The weighted value of the gain distribution G is defined as follows

$$WV(G) = \sum_{i=1}^{n} \pi_i v(g_i)$$

and the certainty-equivalent value, g^*, defined as the riskless gain that produces the same weighted value as the risky prospect G, is the solution to the following equation

$$v(g^*) = WV(G).$$

A positive value of g^* implies that the policy that generates outcome distribution Y is preferred (with respect to this outcome) to the reference policy that generates outcome distribution X. And conversely, if g^* is negative, the reference policy is preferred. This means that $g^* = 0$ implies indifference between the two outcome distributions and the policies that generate them.

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