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The Effect of Defined Contribution Plans on the Retirement Decision

Wonku Hong

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THE EFFECTS OF DEFINED CONTRIBUTION PLANS ON THE RETIREMENT DECISION

BY

WONKU HONG

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in the Robinson College of Business
Of
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Acceptance

This dissertation was prepared under the direction of Wonku Hong's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Robinson College of Business of Georgia State University.

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ABSTRACT

THE EFFECTS OF DEFINED CONTRIBUTION PLANS
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BY

WONKU HONG

2005

Committee Chair: Dr. David P. Richardson

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This study examines the effects of pensions on the retirement decision, focusing on the differences between defined benefit (DB) plans and defined contribution (DC) plans. I find that DC plans have different effects on the accumulation of retirement wealth, the incentives for retirement and the risk of retirement benefits than DB plans. Thereby, DC plans have different effects from DB plans on the decision to retire. This paper is the first empirical study to investigate the effect of longevity risk in pension plans on retirement. It is an important addition to the literature on retirement behavior since longevity risk will become more important as individuals have longer life expectancies and bear more longevity risk due to increasing likelihood of coverage by DC plans or Social Security personal accounts.

Previous research has found that DB plans have an age-incentive effect on retirement. That is, the structure of DB plans may induce individuals to retire at a specific age. By contrast, the structure of DC plans does not have age-incentive effects. Thereby, individuals with DC plans may retire either earlier or later on average than individuals with DB plans because of the absence of age-related incentives in DC plans. To shed further light on these issues, this study introduces risk factors, and particularly longevity risk, to an option value model of the retirement decision. Longevity risk is important to

DC participants since DC plans usually offer a lump-sum benefit at retirement. Since payouts are not guaranteed over life expectancy, retirees with DC plans bear a greater risk of outliving their resources, i.e., longevity risk. The additional risks in DC plans may make workers save more, and retire later.

This paper extends a standard intertemporal model of consumption and retirement by incorporating risk factors for different pension types into the retirement decision problem. Comparative statics from the optimal solution show that increases in risk factors (i.e. longevity risk) during retirement induce workers with DC plans to retire later than workers with defined benefit (DB) plans. This study then tests the predictions of this model empirically, using the data from the Health and Retirement Study (HRS). Empirical results confirm the predictions of the theoretical model. First, workers with DC plans expect to retire later than workers with DB plans. Next, increase in pension option value, measured as the difference between the maximum pension value and the pension value of 1992, decreases the probability of retirement, thereby increasing the expected retirement wage. By contrast, greater pension wealth increases the probability of retirement, reducing the expected retirement age. Considering that pension wealth in DC plans is about half of pension wealth in DB plans, it is reasonable to conclude that workers with DC plans retire later than workers with DB plans. Finally, longevity risk, as measured by the Annuity Equivalent Wealth (AEW), decreases probability of retirement, increasing the expected retirement age.

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I. Introduction

This study examines the effect of pensions on the timing of retirement, focusing on the differences between defined benefit (DB) plans and defined contribution (DC) plans. The motivation for this research is from increases in expected longevity for the general population, the gradual shift from employer sponsored DB plans to DC plans since the 1980s, and the possibility of changing the structure of Social Security from a pure DB plan to one that incorporates DC type personal accounts. Using an intertemporal model of the retirement decision that specifically incorporates DC plan specific longevity risk, I find that DC plans have different effects on the accumulation of the retirement wealth, the incentives for retirement and the risk of retirement benefits than DB plans. Thereby, DC plans have different effects from DB plans on the decision to retire. This paper is the first empirical study to investigate the effect of longevity risk in pension plans on retirement. It is an important addition to the literature on retirement behavior since longevity risk will become more important as individuals have longer life expectancies and bear more longevity risk due to increasing likelihood of coverage by DC plans or Social Security personal accounts.

The growth in the coverage and benefits of private pension plans has been considered one of the major factors to reduce the labor force participation rate in old workers (Kaufman and Hotchkiss, 2000, p 134). A number of studies have found that the growth of DB plans has decreased the retirement ages of men during the second half of twentieth century in the United States (e.g. Anderson, 1999). Traditional DB pension plans increase the wealth in old age, and provide persons incentives to reduce hours of work or to retire. In particular, DB plans tend to have a particularly strong age-specific retirement incentives, since the marginal accrual of retirement benefits under DB plans starts to decline after a specific age, leading to decline in expected lifetime benefits. Therefore, individual's retirement decision is likely to be strongly influenced by the desire to maximize lifetime retirement benefits.

There has been a gradual shift from DB plans to DC plans since the 1980s. Since the passage of the Employee Retirement Income Security Act (ERISA) in 1974, the role of DC plans has increased in the retirement security system. Form 5500 data indicate that in 1980 61.4 percent of workers were covered by DB plans and 38.6 percent by DC plans. In 1999 these percentages were 31 percent and 69 percent, respectively (Figure 1).[1] DB plans and DC plans have different effects on the accumulation of retirement wealth and the risk of retirement benefits. DC plans are age-neutral by design, and therefore they have none of the age-specific work disincentives that are common in traditional DB plans.

Many earlier studies of retirement have focused on the effect of Social Security and DB plans and have found that DB plans have an age-incentive effect on retirement (Mitchell and Fields (1984), Stock and Wise (1990) and Samwick (1998)). While a number of researchers have studied the effect of DC plans on savings since the 1990s, little research has focused on the effect of DC plans on retirement. Friedberg and Webb (2000, 2003) find that individuals with DC plans retire almost two years later on average than individuals with DB plans because of the absence of age-related incentives in DC plans. Munnell, Cahill and Jivan (2003) confirm the delaying effect of DC plans on retirement age, but the expected size of effect is approximately one year. Sevak (2001) studies the effects of the stock market run-up in the 1990s, and shows that an unexpected increase in wealth in the 1990s would lead to an increase in retirement probability among individuals, ages 55 to 60. She also notes that the effect that Friedberg and Webb (2000) found may simply be a wealth effect.

Age-incentive effects in DB plans suggest workers with DB plans near either the early or the normal retirement age may maximize their retirement wealth by opting to retire at the point where the marginal accrual to expected lifetime pension benefits is zero.

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[1] U.S. Department of Labor (2004), Private Pension Plan Bulletin: Abstract of 1999 Form 5500 Annual Reports.

However, it is not clear why non-existence of these financial incentives in DC plans causes workers with DC plans to retire later than workers with DB plans. Workers with DC plans may work longer since DC plans do not have a normal retirement age clause, and the present value of pension benefits does not decline like DB plans. Workers with DC plans may also retire earlier, since they do not have to consider the normal retirement age, i.e., there is no big increase in pension benefits under DB and no incentive to defer retirement. To shed further light on these issues, this study introduces one more factor that may affect the retirement decision, the difference in risk sharing between DB plans and DC plans. The individuals with DC plans are responsible for their investment risk during the accumulation period. DC plans usually offer a lump-sum benefit at retirement. One of the primary concerns about lump-sum distributions is that retirees will spend their money too fast during the initial phase of their retirement depleting their resources before they die (McGill, Brown, Haley, and Schieber, 2005, p.444). Since payouts are not guaranteed, retirees have to bear the longevity risk as well as the investment risk after retirement (Brown, 2000). As Mankiw (1999, p.454) says, the workers with DC plans may respond to this uncertainty by saving more in order to better prepare for these contingencies. These precautionary savings may require a longer working period. Sheshinski (2004) also suggests that longevity risk can affect the retirement timing. The additional risks in DC plans may make workers save more, and retire later.

Considering the increasing share of retirement savings is facilitated by DC plans, it is important to understand the effect of DC plans on retirement. For example, after a long period of decline, the labor participation rates of older men stabilized or even increased slightly after 1985. The gradual shift from DB plans to DC plans since the early 1980s may be a reason for the slowdown or reversal of retirement trends in recent years (Quinn, 1999). This issue will become more important in the future if individuals are expected to bear more risk in accumulating their retirement income and more longevity risk due to increasing numbers of DC plans or Social Security privatization. Social Security privatization may increase labor supply, since the privatization will increase the longevity risk (Nishiyama and Smetters (2005)).

It is fair to say that much of U.S. retirement security policy over the past 70 years has been commingled with labor force policy.[2] Given that the baby boom generation in U.S will start to retire soon in large numbers, labor market policies that encourage the old worker in the labor force may be necessary. However, if individuals with DC plans retire later due to their anxieties concerning an unstable retirement income, policy makers should consider DC pensioners' difficulties in designing future retirement systems. This has implications for the current debate over Social Security reform. If Social Security is privatized, the reform should incorporate a mechanism that helps diversify longevity risk. For employers, DB plans have been a tool to induce older workers to retire. If DC plans have no incentive effects like DB plans and workers with DC plans have concern about longevity risk, employers should consider the adoption of a more favorable annuity clause in their DC plans to achieve their objectives. If employers are unwilling to offer more favorable annuity terms, then Congress can enact legislation requiring partial or full annuitization of DC account balances.

The next section discusses the implications of DC plans for retirement, and provides a brief review of the previous studies on the effect of pensions on retirement. Section III describes the model, data and estimation process. Section IV presents the estimation results and explanations. Section V concludes with some findings from this analysis.

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[2] Indeed, DB retirement rules have historically been designed to encourage older workers to exit the labor force.

II. Literature Review

1. Historical and Institutional Background

This section will provide the overview of the historical and institutional background of the U.S. labor markets and private pensions. The overview covers retirement trends, the shift of private pension coverage from DB plans to DC plans, and the description and the comparison of DB plans and DC plans.

The labor force participation rates of men, particularly of older men have decreased for the last 40 years in the United States. In 1950, 72 percent of men aged 65 were still in the labor force, as were 81 percent of those aged 62 (Figure 2) (Quinn, 1999). By 1970, the participation rate for men aged 62 had dropped to 74 percent. By 1985, only half of those aged 62 were still in the labor force. By this time, the participation rate for men aged 65 had dropped to 30 percent, while the rate for men aged 70 was only 16 percent. After a long period of decline, the participation rates of older men stabilized or even increased slightly after 1985. The growth of the coverage and benefits from Social Security and private pension plans is considered an important reason for the decline in participation rates among older men (Kaufman and Hotchkiss, 2000, p. 133-137). Other important reasons include the inverted-U type lifecycle pattern of real wage rate, long-run rise in real wages, the growth in disability benefits, increases in average household wealth, and decreased demand for low-skilled workers.

Pension coverage, participation, and benefits grew rapidly between the early 1940s and the 1970s. Between 1940 and 1973, the number of retirees receiving pension benefits increased from 200,000 to 6 million and the number of covered employees rose from 4.1 million to 35 million. The growth of pension coverage in the early postwar period is estimated to account for one-fourth of the contemporaneous decline in labor force participation rates (Samwick, 1998). In addition to the growth of private pension plans, the shift from DB plans to DC plans is another remarkable characteristic in the U.S pension history. Since ERISA in 1974, the majority of new plans have been DC plans. Form 5500 data indicate that in 1980 61.4 percent of workers were covered by DB plans and 38.6 percent by DC plans. In 1999 these percentages were 31 percent and 69 percent, respectively. The shift from DB plans toward DC plans is also reflected in the number of pension plans. The number of DB plans increased from 148,096 in 1980 to 175,000 in 1983, but then decreased to 101,000 by 1990, and to 56,405 by 1998 (Figure 1). By contrast, the number of DC plans doubled over the same period, from 340,805 in 1980 to 673,626 in 1998. A result of this shift in coverage is that assets in DC plans began accumulating more rapidly than those in DB plans. By 1997, assets of DC plans also surpassed assets in DB plans beginning with 1997. The reasons behind the shift include tax advantages, the cost of plan administration and the federal government's implicit emphasis on DC plans (Allen, Melone, Rosenbloom, and Mahoney, 2003). [3]

Before discussing specific impacts of pension types on retirement, it is important to understand the basic aspects of pension types. Private pensions are typically classified into two broad types according to the obligations assumed by an employer. The obligations may take one of two forms: (1) to provide benefits according to a specific schedule, or (2) to contribute funds on a specific basis (McGill et. al., 2005, p. 236). By law, DB plans provide definitely determinable benefits, usually based on an employee's service and/or pay, while DC plans provide fixed contributions and base benefits solely on the contribution and accumulation.

In a DB plan, the amount of benefits, and the forms and the time of payment are established in advance by rules, and employer contributions are considered a variable factor. Two basic forms of benefit formulas are the unit benefit formula and the flat

[3] Allen et al. (2003) provides the backgrounds of the historical preference for DB plans over DC plans (pp.48-50).

benefit formula. The unit formula credits an explicit unit of benefit (as a percentage of compensation or as a specific dollar amount[4]) for each year of service. The unit of benefit can be based on the compensation during every year (the career average formula) or the participant's average compensation during a specific period (three, five, or 10 years) before retirement (the final average formula). A flat benefit formulas provide a benefit at retirement equal to a specified percentage (e.g. 30, 40, or 50 percent) or flat dollar amount of compensation (normally average earnings during a specific period before retirement), without regard to years of service. The second important aspect of retirement benefits in DB plans is the time of payment. Since most DB plans promise to pay a retirement benefit throughout the remaining lifetime of the retired employee, the forms of benefit is typically an annuity and DB plans specify the age from which payment of benefit may start. However, some plans allow taking a lump-sum distribution of the present discounted value of the expected lifetime benefits. Under this condition, participants can receive the full amount of accrued benefits upon retirement or after reaching a specified age (normal retirement age).[5] In many DB plans, a participant may retire earlier than the normal retirement age with reduced benefits, subject to specified conditions. Many employers frequently use early retirement factors that are more favorable than the actuarially fair reduction factor to induce early retirement.

DC plans define the amount of contribution to a participant's account. There are various types of DC plans: money purchase pension plans, profit-sharing sharing plans, stock bonus plan, employee stock ownership plan, cash or deferred plans under Section 401(k), thrift and savings plans and 403(b) plans.[6] Under a money purchase plan,

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[4] A percentage unit is the usual procedure under a plan for salaried employees (McGill et al., 2005, p.236), and a dollar amount unit tends to be found in a collectively bargained plan.

[5] By law, the normal retirement age not later than age 65 should be specified in the plan.

[6] See, for example, McGill's (2005) chapter 11 and Allen et. al. (2003) chater7- chapter12 for the detailed descriptions of each form of DC plan.

employer contributions are fixed as a percentage of pay or as a flat dollar amount. On the contrary, under profit sharing plans contributions are variable according to profits are made on a discretionary, voluntary basis. A stock bonus plan is similar to a profit-sharing plan, except that benefits are distributed in stock of the employer company. An employee stock ownership plan (ESOP) invests in employer stock. An ESOP should be either a stock bonus plans or money purchase plan. Under 401(k) plans, employees can choose to take compensation in the form of cash or as a tax-deferred contribution accumulated in a qualified retirement saving account.[7] Under a thrift and savings plan employees make voluntary after-tax contributions to their accounts. Finally, a 403(b) plan is a kind of DC plan for employees of public educational institutions and certain nonprofit tax-exempt organizations.

DB plans and DC plans have different characteristics and relative advantages to employers and employees. For example, DC plans typically have shorter vesting periods and, since the advent of section 401(k) in 1978, employee pre-tax elective contributions are an important component of DC pension wealth. Many workers also prefer DC plans because of portability between jobs.[8] While these differences may be important to plan selection by employers and job sorting among employees, they do not inherently impact the retirement decision. However, differences in the risk characteristics of DB and DC pensions may inherently affect the retirement decision. One of greatest sources of risk to a worker participating in a DC plan is the investment performance of the fund (Bajtelsmit and Vanderhei, 1998). For workers who voluntarily fund their DC plans, underfunding provides another source of retirement risk. In DC plans, ultimate retirement income is dependent on the level of contributions made to the plan, investment performance of each

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[7] This feature is referred to a Cash Or Deferred Account (CODA).

[8] However, if the contribution rate is related to service year, the portability of DC plans will decrease (Bodie, Marcus, and Merton, 1988).

participant's account, and the length of time between contributions and distributions. By comparison, DB plans typically provide retirement benefits based on years of service and level of pay during the last few years before retirement. By law, employers are typically responsible for insuring that the pension trust is adequately funded, both by funding accruing liabilities and by replacing any assets lost due to poor investment performance. Thus, DC plan participants face much greater uncertainty regarding the expected level of retirement benefits and increasing short-term investment risk as they approach retirement. By comparison, the benefits in DB plans become more certain as employees approach retirement. It has been argued that the shifting of risk to employees is detrimental to retirement income security. Workers with DC plans likely face more risks after retirement than those who have DB plans. Retirees with DC plans must decide how to invest the money and should bear the related risk. The investment risk should be considered in valuing the pension wealth.

2. Retirement Wealth

Pensions impact the retirement decision by changing the structure and level of retirement wealth. The wealth effect of pensions on retirement can be analyzed in the framework of labor-leisure model. The income effect occurs because pensions increase the retirement income of a potential retiree. Assuming leisure is a normal good, the demand for leisure increases as expected income rises. Pensions also change the cost of retirement leisure to the worker. The cost of retiring a year earlier is the lost earnings. If the replacement rate is 100%, then the price of leisure is zero. Since replacement rate is less than 100%, there is a price to be paid by retiring (Bruce, 2001, p.266). All else equal, workers should balance the benefits of retiring earlier against the cost of a smaller monthly payment.

The literature on effects of pension wealth on retirement can be classified into two groups. In the first group, a broad literature attempts to answer the question of whether pensions can affect the retirement wealth. The second group of literature focuses on the wealth effect on the retirement decision. The effect of pension on wealth accumulation has been studied much, even though there remain some disagreements. The main issue is whether pensions savings are new savings or simply shifting out of other, less tax-advantaged forms of savings. The life-cycle hypothesis implies that pensions should offset non-pension wealth dollar-for-dollar. Many empirical studies find that pension wealth reduces non-pension wealth, but the reduction is much less than 100 cents per dollar of pension wealth.[9] Social security wealth is also found to offset non-pension wealth.[10] More recently, Gustman and Steinmeir (1999) use the 1992 data of the Health and Retirement Study (HRS) and find that pensions displace only a fraction of other savings, or there is no displacement at all. Gale (1998) emphasizes, however, that the estimated offsets in previous empirical studies are smaller than the true offset because of systematic econometric biases. According to these studies, pension wealth can cause early retirement through increased wealth, even though the total wealth does not increase by the pension wealth because of a partial canceling effect. However, these studies typically do not model or discuss the impact on the retirement decision from the different risk characteristics inherent to pension versus non-pension wealth.

Pension types can influence retirement wealth accumulation and retirement decision. There are some reasons for the retirement wealth from two types of pension plans to differ. For example, considering the differences in the pension formula, the nature of employers and administrative cost, it may be natural to think that the benefits from two types of pension plans will be different. Whether DC plans provide retirement

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[9] For example, King and Dicks-Mireaux (1982).

[10] The effects of Social Security on saving are summarized well in Feldstein and Liebman (2002).

benefits comparable to DB plans is an empirical problem. The potential different effect of pension types on wealth has also been studied.[11]

Samwick and Skinner (1998) consider the question how the emergence of DC plans, such as 401(k) plans, has affected the financial security of future retirees, using a detailed survey of pension formulas in the Survey of Consumer Finances. Their simulations show that average and median pension benefits are higher under DC plans than for DB plans, implying that DC plans can strengthen the financial security of retirees. The increased retirement wealth may cause workers to retire early. They also find that DC plans are indeed more risky, in the sense that the variance of retirement income is greater than for DB plans, while the expected returns are higher. According to Even and Macpherson's (1998) simulation using the 1992 Survey of Consumer Finances (SCF) and the Health and Retirement Study (HRS) data, mean and median benefits in DC plans are projected to be greater than in DB plans. However, 401(k) plans generate lower benefits than DB plans for low income workers.

Gustman, Mitchell and Steinmeier (1997) derive different results and conclusions. The mean value of the DC plans in 1992 is significantly below the comparable value for DB plans. One reason for the difference is that cumulative earnings paid to those covered by DC plans are about 20 percent lower than are the cumulative earnings paid to those covered by DB plans. So the results do not contradict Samwick and Skinner's (1998) simulation in which identical earning histories are assumed. Blank (1999) runs a regression of retirement wealth on the pension type dummies and other control variables such as investment strategies in DC plans, using the Health and Retirement Study data. She finds that a DB plan appears to contribute almost $0.8 million toward retirement

[11] A related strand of the literature explores the impact of the booming stock market of the late 1990s on changes in wealth: See Sevak (2001), Gustman and Steinmeier (2002), Coronado and Perozek (2003), Kezdi and Sevak (2004), and Coile and Levine (2004).

resources as compared to individuals without any pension plans. DC plans investing in a combination of stocks and bonds appear to contribute more than $1.33 million dollars to retirement wealth, while other DC plans do not appear significant. She concludes that regression results suggest that workers with DB plans appear to have more retirement resources than those who have no pension or have a DC plan. However, these results may be interpreted as the evidence that DC plans have more variability than DB plans. Friedberg and Webb (2003) find significant differences in pension wealth across pension plans. For 1992, the median pension wealth of those who have both DB and DC plans is $345,156 if the workers retire at age 65, while the amount in DB plans is $203,949. The median pension wealth in DC is the lowest of $102,298. If the wealth effect of pension enables workers to retire earlier, then the workers with DC plans expected to retire later, other things being equal.

The wealth effect on the retirement decision has been studied extensively. Exploiting natural experiments resulting from policy changes, Krueger and Pischke (1992) find little evidence of an increase in labor supply for workers born between 1917 and 1921, and who experienced a dramatic reduction in Social Security benefits due to a law change. Recent research examining the role of wealth shocks more broadly has relied on sources of variation in retirement wealth that are exogenous to an individual's preferences for leisure. For instance, several authors have focused on inheritances and lottery winnings. Joulfaian and Wilhelm (1994) estimate relatively modest effects of inheritances on the retirement decisions of older men. In contrast, Holtz-Eakin, Joulfaian, and Rosen (1993) find that working-age individuals receiving large inheritances are three to four times more likely to exit the labor force than individuals receiving small inheritances. Imbens, Rubin, and Sacerdote (2001) estimate that lottery winners consume about 11 percent of their winnings in the form of reduced labor earnings and that the effect is about one-third larger for individuals aged 55 to 65.

A second related strand of the literature explores the impact of unexpected changes in wealth associated with stock market fluctuations, and largely the boom of the late 1990s, on retirement decisions. Sevak (2001) finds that unexpected increase in wealth in the 1990s would lead to an increase in retirement probability among individuals aged 55 to 60. Other researchers confirm that large positive wealth shocks can reduce labor supply (Cheng and French, 2000; Coronado and Perozek, 2003). Cheng and French (2000), however, also point out that labor force participation rates for individuals aged 55 and older have increased since 1995. Increases in stock market wealth should cause reductions in labor force participation, all other things equal. They conclude that the stock market has not been the dominant factor in influencing labor force participation. Gustman and Steinmeier (2002) finds that the extraordinary returns in the stock market in the late 1990's increased retirement for the HRS sample of workers by over 3 percent by the turn of century and that the subsequent decline in the market neutralized the effect of the preceding stock market gains on retirement. Coronado and Perozek (2003) reach a similar finding that those who received unanticipated equity gains during the market boom of the late 1990s retired earlier than they had anticipated. Using the panel data covering the period 1992 through 2000 from the Health and Retirement Study (HRS), Kezdi and Sevak (2004) explore the effect of bust in stock market and conclude that CPS respondents with dividend income are less likely to retire in 2001 and 2002 than respondents without dividend income. Coile and Levine (2004), however, find little support for an impact of the boom and bust on retirement.

Munnell et al. (2003) report that level of pension wealth in DB plans has a larger effect on reducing retirement age than the counterpart of DC plans. In their regression, the pension characteristics have opposite effects on retirement age: DB plans reduce the retirement age, but DC plans increase the retirement age. However, they do not provide any explanations on why pension wealth has different magnitudes of effect on retirement age or why the pension characteristics (dummies) have opposite sign. These differences may reflect the difference in risk sharing of pension wealth.

To summarize, assuming the normality of leisure, higher wealth reduces labor supply. Many researchers show that increase in wealth from a booming stock market in 1990s prompts workers to reduce labor supply or retire early. Overall, despite some inconsistent results, increased wealth is estimated to accelerate the timing of retirement.

3. Age-specific Retirement Incentives

DB plans are typically structured such that workers are encouraged to retire at specific ages. DB plans generally reward workers for years of service in the form of a higher annual pension during each year of retirement. However, the value of that reward can decline as the worker lengthens his career past the age where the worker's expected lifetime benefit is maximized. The reason is that the worker, at a certain age, foregoing a year of benefits for another year of contributions has a negative effect of expected lifetime benefits. That is, the expected present value of pension benefits is a single-peaked function of age (Lazear, 1995, pp.42-45). DB plans therefore encourage workers to retire at specific dates, that is, at the peak of the pension value. By comparison, DC plans never exhibit single-peaked maximum values. The expected present value of DC plans may rise with age of retirement, since expected pension payments do not directly depend on the number of years left in a person's life (Lazear, 1998, pp.423-424).

In addition, in typical DB plans, pension wealth does not increase smoothly. For example, in retirement plans subject to a vesting schedule, accruals are zero until the individual achieves some vested right. At this point, there is a first accrual spike representing the value of marginal benefit accruals for all prior years of work. From this point on, annual benefit accruals increase smoothly until the worker is eligible to retire and start receiving a pension benefit. Typically, there are large spikes in benefit accruals when the worker satisfies the age and service requirements for early and normal retirement benefits. After the initial age of eligibility has been attained, accrual calculations become more complex, because one must weigh higher benefits in the future derived from continued employment against benefits foregone while the employee continues working. Typically, benefit accruals begin to decline after the age of initial eligibility and can eventually become negative if the individual remains with the firm at older ages. This decline in pension wealth provides an incentive for the worker to leave the firm.

Kotlikoff and Wise (1987) estimate pension accruals, that is, the increment to pension wealth in excess of the return on the previously accumulated pension account. They find that pension plans provide substantial incentives to quit work after early retirement age and greater incentives to leave after normal retirement age. They calculate the pension accrual as a percentage of wage at each age.[12] Figure 3 shows the pension accruals. The typical pension plans (10 year cliff vesting, early retirement age 55, normal retirement age 65) that Kotlikoff and Wise (1987) use for calculating pension accruals provides 62.57 percent of pension accruals to workers at age 34 who started work at age 25. The pension accruals increase continuously up to early retirement age 55, but after early retirement age, the pension accruals start to decrease and become negative after

[12] Vested pension benefit accrual at age a, I(a), is equals the difference between pension wealth at age a +1, Pw (a+1) and pension wealth at age a, Pw(a), accumulated to age a+1 at the nominal interest rate r, that is, I(a) = Pw(a+1) – Pw(a+1)(1+r). Pension wealth at age a is defined as the expected value of vested pension benefits discounted age a. Figure 2 shows the ratio of I(a) to W(a) for a worker age a with t years of service. Worker is assumed to start to work age 25.

normal retirement age 65.[13] Cumulative pension wealth keeps increasing up to normal retirement age and starts to decrease after normal retirement age.

There is an extensive literature on the influence of pension incentive on individual retirement decisions. Much of the research has focused on annual pension accrual, since it is the central mechanism by which pension plans affect individuals' retirement decisions. DC plans, however, have a different structure. Recently, some researchers have examined the differences between DB plans and DC plans. Mitchell and Fields (1984) examine the role of economic factors in determining retirement behavior using a unique archive on more than 8,700 workers covered by ten different pension plans. Their results indicate that persons with more income retire earlier, and that individuals who have more to gain by postponing retirement retire later. They also find that lifetime benefits were maximized at age 62 or earlier in nine of the ten plans. Lazear and Moore (1988) suggest that by delaying retirement individuals retain the option to retire at a later date, under potentially more advantageous terms and that turnover at a point in time depends on future considerations as well as current ones. They demonstrate that a ten percent increase in the option value of retirement pensions reduces the probability of turnover for old workers by 22 percent, using the profiles of hypothetical employees under the six different plans.

Stock and Wise (1990) propose the "option" model, which incorporates Social Security accruals and pension accruals into the analysis, and estimated total annual compensation for a cohort of workers in a single firm, for every age in the future. In every year, workers have the option to retire now or delay the retirement until the next year. They value this right to choose the retirement timing by comparing the pension

[13] According to employer's personnel policy, the benefit accrual pattern may be different. McGill et al. (2005, p.502) points out DB plans do not work exactly as Kotlikoff and Wise analyzed them in the treatment of early retirement supplements or the availability of lump-sum distribution.

benefits that can be received if workers retire today and the pension value that can be received if they retire later plus the earnings to retirement. Predicted departure rates based on the model corresponded closely to actual departure rates. In particular, discontinuous jumps in retirement rates from 54 to 55 and from 61 to 62 are captured by the model predictions. Samwick (1998) extends Stock and Wise's analysis to a broader sample, by combining the demographic, employment and wealth data on older households in the 1983 and 1986 Survey of Consumer Finances (SCF) with detailed pension information provided by employers in a special SCF supplement. He shows that results of Stock and Wise (1990) model based on one firm's data still remain valid. Samwick finds that retirement wealth accruals are more important than retirement wealth levels, and that it is pension wealth, not Social Security wealth, that primarily determines the change in retirement wealth. He estimates that about one-quarter of the decline in labor force participation of older men between 1955 and 1975 was due to expanded pension coverage. Increasing coverage by approximately 50 percent generates a reduction in labor force participation of about 5 percentage points. This reduction is roughly 27 percent of the actual reduction that occurred during the period when pension coverage was extended by this amount.

Friedberg and Webb (2003) analyze the effects of pension types on retirement decisions, using the Health and Retirement Survey (HRS). Their estimates indicate that financial incentives in DB plans lead people to retire almost two years earlier on average, compared to people with DC plans. Chan and Stevens (2004) employ a fixed-effect regression technique to control for unobserved heterogeneity and investigates the effects of pension wealth accumulations measured by peak value on individuals' retirement expectations. They find significant effects of future pension wealth accumulation on retirement expectations.

Many researchers have found that DB plans have an age-incentive effect on retirement. However, why the financial incentives in DB plans cause workers to retire earlier than workers with DC plans is not clear. When there is no age incentive to retirement in DC plans, why do workers with DC plans retire later than worker with DB plans? They may retire earlier, since they do not have to consider the normal retirement age. If workers with DC plans retire later without any constraint such as an age-incentive in DB plans, this implies there are other constraints that prohibits workers with DC plans from leaving the labor force early. That is, the cause that enables workers with DB plans to retire early may be a simple wealth effect. The evidence from the 1990s stock market boom shows that if workers with DC plans have enough retirement wealth, then they may retire early. As discussed next section, the increased longevity risk in DC may be another factor that induces workers with DC plans to retire later.

4. Longevity Risk

One of the important risks that a retiree with DC plans bears is the longevity risk. Longevity risk means the risk that one outlives one's wealth. Longevity risk comes from the fact that a retiree's remaining lifespan is not a certain period. DC plans typically offer a lump sum, while DB plans offer a life annuity that deals with longevity risks. Workers with DC plans may either spend their money too fast during the initial phase of their retirement, depleting their resources before they die or they will spend it too slowly, conserving capital just in case they live an unexpected long life. In both cases, the retirees will end up with having less disposable income to meet retirement consumption needs than is optimal for some period of their retirement (McGill et. al. (2004), p.444). Considering higher longevity risks, workers with DC plans may desire a higher level of wealth in retirement to maintain equivalent level of consumption. In order to save more, workers may choose to retire later. Kotlikoff and Spivak (1981) show that annuities can increase the utility by eliminating the longevity risk. In their model, the consumption path with annuity market attains constant consumptions, while the consumption paths without an annuity market have a negative slope.[14]

Having lump-sum retirement benefits at the end of their career does not mean that these individuals have to bear longevity risks. Some DC plans provide annuitization options and even when DC plans do not provide any annuitization option, individuals can buy annuities from private markets. Individuals can deal with longevity risk by converting their retirement savings into steady and reliable income streams over their remaining lives, i.e., buying an annuity at retirement with savings. Brown (2000) points out that lump-sum payments in DC plans fail to provide a formal mechanism by which individuals can insure against longevity risk, and suggests that annuities are a way of insuring against longevity risk. One of the main issues concerning annuitization of retirement benefits is how many workers are willing to annuitize and actually annuitize their retirement wealth. Brown (2001) examines household decisions about whether or not to annuitize retirement resources, using the HRS data.[15] He runs probit regression of dummy variable for the willingness to annuitize balances in DC plans on the annuity equivalent wealth and other control variables. He finds that a one-percentage point increase in the annuity equivalent wealth leads to nearly a one-percentage point increase in the probability of annuitizing balances in DC plans. Contrary to theoretical prediction, in reality, many retirees do not choose annuity options and demand for annuities is lower than theoretical predictions.[16] For example, Moore and Mitchell (2000) report that Social

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[14] The slope of consumption path depends on the degree of relative risk aversion. The higher the degree of relative risk aversion, the flatter the slope of the consumption path.

[15] In Brown (2001), nearly half of the 869 observations report that they will annuitize their DC plans.

[16] According to Yarri's (1965) models, individuals without bequest motives should fully annuitize their wealth.

Security and pension wealth constitutes half of older American household's wealth and almost 40 percent of household wealth is held in non-annuitized financial wealth. The proportion of non-annuitized wealth is higher in wealthier households. Brown (2000) explains various reasons[17] why more people don't buy annuities. The price of annuities during the retirement period is also an important issue. In a private annuity market with adverse selection, the price of an annuity at retirement should be higher than the price of an annuity that is bought at young age. Mitchell, Poterba, Warshawsky and Brown (1999) find that a typical retiree with average mortality prospects faces a significant cost if he purchases an individual annuity from a commercial insurance company, even though the payout value-per-premium dollar has risen from the early 1980's to mid 1990's. The risk in annuitization at retirement is essentially related to the interest rate under which pension wealth can be transformed into an annuity. Bodie et al. (1985, p.145) consider deferred life annuities at fair interest rates one of important advantages in DB plans that can be welfare improving and that are not available in capital market. In short, even after the annuitization at retirement is considered, longevity risk in DC plans still matters.

Although there is little research on risk difference between pension types on retirement, some researchers have studied the effects of mortality risk and longevity risk on retirement. Hurd and Smith (2002) study the effect of subjective survival on retirement. They find that workers with a very low survival probability leave the labor force earlier than those with moderate or high survival probabilities. Alternatively, researchers have studied the effect of longevity risk can be found in macroeconomic level. Bloom, Canning, and Graham (2003) show that increase in life expectancy leads to

[17] Various explanations were explored to answer the thin market for annuities: the role of adverse selection, administrative loading factors, bequest motives, precautionary savings, and the risk pooling within family.

higher saving rates at every age under a couple of assumptions[18] and find empirical support, using a cross-country panel of national saving rates in East Asian counties. They find that when life expectancy increases, the effect of increased longevity on retirement income outweighs the effect of improved health on the length of working life. That is, increased longevity risk increases the need for retirement income. The need for retirement income boosts savings. Nishiyama and Smetters (2005) find that longevity risk increases labor supply and precautionary savings. They analyze the effects of simulated phased-in partial privatization of Social Security. According to their analysis, labor supply increases by 3.5 percent in the long run without perfect annuity market, and labor supply increases only 3.2 percent in the long run with perfect annuity markets. The decrease in labor supply with perfect annuity market shows the longevity risk can induce workers to increase their labor supply or defer retirement. Sheshinski (2004) also shows that longevity risk can affect the retirement timing. He suggests that optimal retirement age is lower with continuous annuitization (i.e., to convert savings continuously during the working period into annuities) than with annuitization at retirement, and that retirement age is lower with annuitization at retirement than without annuitization. Because DB plans may be continuous annuitization and that DC plans may be annuitized at retirement or provide a lump-sum, workers with DB plans may retire earlier than workers with DC plans.

5. Other Factors Affecting the Retirement Decision

In addition to pension factors mentioned above, there are several factors that powerfully influence workers' retirement decisions. Prominent among these other factors

[18] The authors assume that agents know their lifetime. The possibility of a bequest motive in saving is ignored. The time path of health is assumed to be exogenously fixed

considered in the retirement literature are the role of Social Security, employer provided health insurance and poor health.

Social Security plays an important role in the retirement decision as DB plans (Feldstein and Liebman, 2002). Social Security will transfer income from working years to retirement years and this transfer will expand the budget constraints in the retirement period. The Social Security benefit structure alters retirement incentives since the benefits will be provided only after individuals retire and the present value of benefits depends on retirement timing. Although any individual's Social Security benefit is adjusted according to the retirement timing, the adjustment is not actuarially fair enough to offset the total changes in the present value of benefits. There is a vast literature that attempts to evaluate the effects of Social Security on retirement. Diamond and Gruber (1999) use the March 1994 and 1995 Current Population Survey (CPS) and find that the retirement rate for men increased dramatically at age sixty-two, which is the age of eligibility for early retirement under Social Security, and at age sixty-five, which is the normal retirement age. Coile and Gruber (2004), using the first four waves of HRS data, show that Social Security wealth and forward-looking measures such as the option value and the peak value are important for explaining retirement behavior, while accrual variable is not.

The substantial body of literature on health insurance and labor force participation includes the issue of the retirement decision. There are three main sources of health insurance for older individuals: employer-provided retiree health insurance, federal government health insurance (Medicare and Medicaid), and commercial individually purchased health insurance. Non-portable employer-provided health insurance tends to reduce job mobility, i.e., have job lock effects. This effect can affect older workers who are close to retirement age. If health insurance loss is costly, then insurance coverage will motivate continued work. However, if employer-provided health insurance is available for retirees, then coverage for employer-provided health insurance does not affect the retirement decision. Madrian (1994) measures the importance of "job lock" effect, i.e. the reduction in job mobility due to the non-portability of employer-provided health insurance. Using 1987 National Medical Expenditure Survey (NMES) data, she finds that job lock reduced voluntary quit probability by 4 percentage points, from 16 percent to 12 percent, equivalent to a 25 percent reduction in job mobility. Kapur (1998), however, using the same 1987 NMES data, finds that job lock effect was small and statistically insignificant. Madrian and Gruber (1995) estimate the effect of continuation of coverage provided under Consolidated Omnibus Budget Reduction Act (COBRA) of 1986 on retirement,[19] using March Current Population Survey for the years 1980-1990 and the 1984-1987 panels of the Survey of Income and Program Participation. Their estimation results suggest that one year of continuation coverage raises the retirement rate by 30 percent.

Buchmuller and Valletta (1999) examine the effects of employer provided health insurance on the labor supply of married women. Since health insurance is commonly provided only to full time workers, spouses who prefer to work short hours, but have no alternative source of insurance, may work long hours in order to get coverage for their families. Using the April 1993 Current Population Survey (CPS) Employee Benefits Supplement, they analyze wives' labor supply. Their empirical analysis employs the reduced form equation that includes a dummy variable representing husband's health insurance. Their results show that the coefficients on husbands' health insurance status and offers were significantly negative, implying that husbands' health insurance coverage reduces married female labor supply. Rogowski and Karoly (2000) demonstrate that access to post-retirement health insurance has a large effect on retirement. Older male workers with retiree health insurance are about 11 percent more likely to retire than

[19] This bill requires employers to offer continued coverage to displaced workers, albeit at full cost to the former worker.

counterparts who would lose employer-provided health insurance upon retirement. However, this may overestimate the true effect due to potential self-selection bias. If workers who expect to retire early select into jobs with retiree health benefits, then this would tend to bias the coefficient on retiree health insurance upward. Thus this, estimate may best be interpreted as an upper bound of the effects of health insurance on retirement. Blau and Gilleske (2003), however, suggest changes in health insurance, including access and restriction to retiree health insurance, have only a modest impact on the employment behavior of older males from their simulation using HRS data.

The role of poor health is thought to have effects on retirement through two different channels – by changing the budget constraint, and preferences (Lumsdaine and Mitchell, 1999). Poor health has a detrimental effect on labor earnings. Many ill employees will be less productive in the short run, and be less likely to invest in long-term skills in the long run. In response to lower pay, unhealthy workers might be more likely to leave their jobs, reduce hours, and eventually retire. Poor health can alter the value of peoples' time and people's perception of the utility of work versus leisure. Dwyer and Mitchell (1998) use HRS data and find a strong correlation between subjective physical health problems with early planned retirement. Men in poor overall health expected to retire one to two years earlier. This effect persists after correcting for potential endogeneity of self-rated health problems. However, they do not relate this result with the pension benefits. Since poor health can shorten life expectancy, individuals may want to retire early to maximize pension the benefit (Hurd and Smith, 2002).

The relationship between bequest motives and retirement decisions has been explored little. However, suppose that individuals save not only for themselves but for the sake of their families, bequest motives should have an influence on the individual's financial decision and savings and should have some impacts on the retirement decision.

Munnell, Sunden, Soto, and Taylor (2003) show that intended bequests and unintended bequests increase as retirees receive more of their pension benefits as lump sums rather than as annuity payments. A probit regression[20] for those aged 51-61, HRS 1992 shows that DC wealth as a share of total retirement wealth (DB, DC and Social Security) has positive significant effect (0.206 measured by marginal effect). Alternatively, a Tobit regression using the probability of a large bequest as dependent variable shows the same effect. These results imply that DC plans have some impacts on the retirement decision through the intended bequest motives and wealth accumulation. Hurd and Smith (2001) find that increases in household wealth are associated with increases in bequest probabilities.

[20] The dependent variable is the indicator variable with a value of one if the household expects to leave a bequest of $10,000 or more, and zero if the household does not.

III. Model and Estimation

1. Model

This study extends the model used by Samwick (1998a) by adding a risk factor. A standard intertemporal model of consumption, $\{c_s\}$, and retirement, R, is given by:

$$\max_{\{c_s, R\}} \int_t^R e^{-\delta(s-t)} u(c_s, 0)\, ds + \int_R^T e^{-\delta(s-t)} u(c_s, 1)\, ds \tag{1}$$

$$\text{s.t.} \quad A_t = \int_t^T e^{-r(s-t)} c_s\, ds - \int_t^R e^{-r(s-t)} y_s\, ds - \int_R^T e^{-r(s-t)} p_s(R, \alpha)\, ds \tag{2}$$

where $\{y_s\}$ is an exogenous stream of income received while working, $\{p_s(R, \alpha)\}$ is a stream of retirement benefits that depends explicitly on the date of retirement R and risk factor α, δ is discount rate, r is the interest rate, and A_t is current wealth at time t. $u(c, 0)$ means the utility from consumption before retirement and $u(c, 1)$ means the utility from consumption after retirement.

A continuous time framework is assumed that the maximand is continuous in the date of retirement. It is also assumed that benefits are a differentiable function. The Lagrangian is:

$$\begin{aligned} \max_{\{c_s, R\}} \quad L = & \int_t^R e^{-\delta(s-t)} u(c_s, 0)\, ds + \int_R^T e^{-\delta(s-t)} u(c_s, 1)\, ds \\ & + \lambda \left[A_t - \int_t^T e^{-r(s-t)} c_s\, ds + \int_t^R e^{-r(s-t)} y_s\, ds + \int_R^T e^{-r(s-t)} p_s(R, \alpha)\, ds \right] \end{aligned} \tag{3}$$

The first-order condition for R is:

$$\frac{\partial \mathrm{L}}{\partial R} = e^{-\delta(R-t)}u(c_R,0) - e^{-\delta(R-t)}u(c_R,1)$$

$$+\lambda[e^{-r(R-t)}y_R - e^{-r(R-t)}p_R(R) + \int_R^T e^{-r(s-t)}p_s{}'(R,\alpha)ds] = 0 \tag{4}$$

Equation (4) can be rearranged as equation (5). [21]

$$e^{-\delta(R-t)}[u(c_R,1) - u(c_R,0)]$$

$$= \lambda\ e^{-r(R-t)}[(y - p_R(R)) + \int_R^T e^{-r(s-R)}p_s{}'(R,\alpha)ds] \tag{5}$$

where λ is the shadow value of the constraint in equation (2) and can be interpreted as the marginal utility of wealth.

The left side of the equation (5) is the gain in utility that result from a marginal decrease in the retirement date. The right side of the equation (5) is the utility value of the change in financial resources that results from a marginal increase in the retirement date. The first term in brackets is the difference between earnings and retirement benefits at retirement time R; this is the immediate financial incentive to delay retirement. The second term is the present value at retirement time R of the increase in retirement benefits that result from a marginal delay in the retirement date. Pension formulas that provide strong incentives to delay the retirement will have larger values of this term. Equation (5) suggests that an important consideration in the decision to retire is the increase in pension wealth that results when retirement is delayed.

When pension benefits have more risks (e.g. longevity risk or investment risk) and the present value of pension benefits should be discounted with higher discount rate,

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[21] Since the notation in Equation (4) assumes c_R is the same regardless of whether the individual is retired at R, the first and the third term on the right hand side of equation (4) should be deleted. The power term $-r(s-t)$ in the last term on the right hand side of equation (4) is same as $-r[(R-t)-(s-R)]$.

the decrease in pension benefit will increase the utility from the marginal increase in the retirement date.

Comparative static shows the effect of risk factor on retirement timing R. Since $sign(\frac{\partial R^*}{\partial \alpha}) = sign(\frac{\partial^2 L}{\partial \alpha \partial R})$ (Varian, 1992), the sign of derivative of equation (5) shows the effect of risk factor on retirement timing R.

$$\frac{\partial^2 \mathrm{L}}{\partial \alpha \partial R} = \lambda\ e^{-r(R-t)}[-p'(R^*, \alpha) + \int_R^T e^{-r(s-R)} p_s''(R^*, \alpha) ds] > 0 \quad (6)$$

The first part of equation (6) $[-p'(R^*, \alpha)]$ is positive, since $p'(R^*, \alpha)$ is negative. The value of pension benefit is sum of present value of future benefits: p = PV ($1 benefits) = $\int e^{-\alpha t} dt$. The benefits should be discounted according to the risk, i.e., high risk requires high discount rate:

$$\frac{\partial \mathrm{p}}{\partial \alpha} = \int - te^{-\alpha t} dt < 0$$

$$\frac{\partial^2 \mathrm{p}}{\partial \alpha^2} = \int t^2 e^{-\alpha t} dt > 0$$

The sign of second part of equation (6) $[\int_R^T e^{-r(s-R)} p_s''(R^*, \alpha) ds]$ is also positive. The sign of p″(R*, α) that can be shown to be positive determines the sign of sign of the second part of equation (6).

$$\begin{aligned} p_s''(R^*, \alpha) &= \frac{\partial^2 \mathrm{p}}{\partial \alpha \partial R} = \frac{\partial^2 \mathrm{p}}{\partial R \partial \alpha} = \frac{\partial}{\partial R} \frac{\partial \mathrm{p}}{\partial \alpha} \\ &= \frac{\partial}{\partial R} \int_R^T - te^{-\alpha t} dt = \mathrm{Re}^{-\alpha R} > 0 \end{aligned} \quad (7)$$

Equation (6) implies that the total effects of increased risks will delay retirement. So far as longevity risk is concerned, DB plans do not affect the risk factor. DC plans increase the longevity risk compared to DB plans, and pension benefits from DC plans should be discounted with higher discount factor. The decrease in pension benefits delays retirement.

This study investigates how pensions affect retirement through pension wealth, age–related incentives, and longevity risk. First, the accumulated retirement wealth will tend to be different depending on whether a worker is covered by a DB plan, a DC plans, both or neither. As noted above, increase in pension wealth provides incentive for earlier retirement. However, whether DB or DC pension wealth is larger cannot be predicted a priori. Second, this study tests the age incentive effect of pension plans on retirement, using pension accruals and measures of pension option value or equivalents. Finally, this study also tests whether higher longevity risk will lead workers to retire later. The research hypothesis is that workers with DC plans will tend to retire later than workers with DB plans, since individuals with DC plans tend to bear more longevity risk than those with DB plans.

More specifically, the model and the research questions lead to the following hypotheses.

Hypothesis #1: Larger pension wealth will cause workers to retire earlier.

Hypothesis #2: Workers with a higher option value will retire later.

Hypothesis #3: Higher longevity risk will cause workers to retire later.

In the next section, I discuss the data and estimation techniques that I use to test these three hypotheses.

2. Data and Estimation

This study employs data from the Health and Retirement Study (HRS). The HRS is a nationally representative survey of over 7,607 households with members who were born between 1931 and 1941. The HRS began in 1992 and surveys participants every two years.[22] The full HRS is comprised of 12,652 individuals, and 7,607 households. Of these, only 8,328 individuals who are age eligible (aged fifty-one to sixty-one in 1992) and who report their working or retirement status are used in the analysis. In addition, individuals with DB plans and DC plans are sometimes analyzed separately in order to more easily compare the two types of pensions.

Various measures of retirement are considered in this study. Individuals are considered retired if they report in the HRS that they consider themselves retired. An individual's expected retirement year is also used. Objective retirement status such as work hours (Friedberg and Webb, 2000) and expected probability of retirement after age 62 may be used in panel data analysis (Chan and Stevens, 2004).

This study employs various estimation approaches corresponding to different retirement measures. The first estimation method is the ordinary least squares (OLS) regression of the expected retirement year. The dependent variable is an individual's expected retirement year as reported at the time of the first wave survey. In this estimation, the sample is reduced to the workers who reported that they were not fully retired in the first wave, since only they were asked to answer the expected retirement year.

The second method of analysis is a probit regression model. Many of retirement models estimate the probability of retirement in year *t* by comparing the observed

[22] Respondents are surveyed in even years regarding household variables in odd years. That is, the 1992 wave is a survey of household status in 1991.

retirement behavior in a sample of workers with the value of a function of their economic characteristics. The most straightforward and frequently used example is a probit model or logit model. A standard specification of retirement is;

$$\Pr\ [\text{Retire in year t}] = \Pr\ [X\beta + \varepsilon > 0],$$

where X is the vector of explanatory variables. Assuming that ε has a normal distribution, this is a probit formulation. The dependent variable in the probit regression model is a dummy variable for retirement. If a respondent reports he or she is retired in a specific year, then this dummy variable takes a value of one, otherwise, the value is zero. Alternatively respondents may be defined as retired when they report as working at wave time t, but report as retired at wave time t+1.

A multinomial logit regression approach is also used. The reason for using this technique is that since many workers often retire in phases, the partial and full retirement need to be defined separately. This study uses the three-alternative version, i.e., an individual faces a three-way choice: (1) retiring fully, (2) retiring partially/ working part-time or (3) working full-time. The three choices are assumed to be unordered.[23] Suppose each individual i faces J choices, and has random utilities corresponding to each choice: $U_{ij} = x'_{ij}\ \beta + \varepsilon_{ij}$, i = 0, 1, 2,..., J, , where x is a vector of exogenous variables and β is a vector of corresponding coefficients to be estimated, and ε is a random shock to utility. If the individual chooses j, then U_{ij} is assumed to be the maximum among the J utilities: Prob ($U_{ij} > U_{ik}$) for all other $k \neq j$. Let Y_i be a random variable that indicates the choice. If the J disturbances are independent and identically distributed with $F(\varepsilon_{ij}) = exp(-exp(\varepsilon_{ij}))$,

[23] If three alternatives are assumed be ordered such as bond rating, then ordered logit or ordered probit analysis may be used. To use the ordered logit/ probit analysis, the equal slope assumption should be hold. When this assumption is not met, the estimates of ordered logit/probit analysis will be biased. However, the multinomial analysis is applied to the ordered choices, the estimates is unbiased, even though those estimates are inefficient.

then Prob ($Y = j$) = exp (x'_{ij} β)/ $\Sigma_{j=1}^{J}$ $exp(x'_{ij}$ β), which is a multinomial logit model (Greene, 2003).[24] The binomial logit model is the special case of J = #2. A interpretation of β is given by Prob(Y=j)/ Prob(Y=0) = exp (x'_{ij} β), j = 1, 2,…, J. Equivalently, the log-odds ratio is linear in x: log [Prob(Y=j)/ Prob(Y=0)] = x β_j (Wooldrige, 2002, p. 498).

Finally, this study uses "time-to-retirement" as the dependent variable, and applies a survival analysis (or duration analysis).[25] Under the survival model,[26] T is assumed be continuous random variable with probability density function $f(t)$ and cumulative distribution function $F(t) = \mathrm{P}(T \leq t)$, giving the probability that the event of retirement has occurred by duration t. Similarly, the complement of F, the survival function, can be defined as: $S(t) = \mathrm{P}(T > t) = 1-F(t) = \int_t^{\infty} f(x)\mathrm{d}x$, which gives the probability of being "alive," in this study "working," at time t. Then, the hazard function is expressed as: $\lambda(t) = f(t)/ S(t)$. For each t, $\lambda(t)$ is the instantaneous rate of occurrence of the event or of leaving per unit of time. In other words, the hazard at duration t equals the ratio between the density of the event at t and the probability of surviving by that duration without experiencing the event. Finally, from the definitions given above, the following relationships hold: $\lambda(t) = -\, d\, log\, S(t)/ dt$, and $S(t) = exp(-\int_t^{\infty} \lambda(x)\mathrm{d}x)$.

The distribution of T can be characterized equivalently both in terms of the survival and the hazard function. However, the shape of hazard function is of primary interest in many empirical applications. When the hazard function is constant, $\lambda(t) = \lambda$. A constant hazard implies survival function $S(t) = 1 - exp(-\lambda t)$, which is the cumulative density function of exponential distribution. When the hazard function is not constant, the

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[24] When data are individual specific, this model is called multinomial logit model. More generally, x may include the attributes of the choices, and then the model is called the conditional logit model (Greene, 2003, p.720).

[25] Hausman and Wise (1985) seminally applied the survival analysis to retirement model.

[26] The descriptions of the survival analysis in this study are based on chapter 20 in Wooldrige (2002) and chapter 22 in Greene (2003).

process is said to exhibit duration dependence. Assuming $\lambda(\cdot)$ is differentiable, there is positive duration dependence at time t if $d\lambda(t)/dt > 0$. With positive duration dependence, the probability of exiting the initial state increases the longer one is in the initial state (Wooldridge, 2002, p.689). The event of interest in this study is retirement, so it is natural to assume that the probability of retiring increases as an individual works longer. Thereby, positive duration dependence in a hazard function is expected in this study. Various distributions capture the positive duration dependence: e.g. a Weilbull distribution, a log-logistic hazard function. If T has a Weibull distribution, its cumulative density function is given by $F(t) = 1 - exp\ (-\gamma t^{\alpha})$, where γ and α are nonnegative parameters. The hazard function is $\lambda(t) = \gamma\alpha t^{\alpha\text{-}1}$. If $\alpha > 1$, the hazard function is monotonically increasing, so hazard exhibits positive duration dependence. The likelihood of failure (in this study, retirement) at time t, conditional on the duration up to time t, is increasing in t. Alternatively, if we assume that hazard increases until a specific point, and then it decreases, then other hazard function such as log-logistic hazard function is preferable. Considering that retirement rates are higher around a specific age, i.e., age 60-62, the curved hazard function may be better than monotonically increasing hazard function. The log-logistic hazard function is specified as $\lambda(t) = \gamma\alpha t^{\alpha\text{-}1}/\ (1 + \gamma\alpha t^{\alpha\text{-}1})$, where γ and α are positive parameters. When $\alpha = 1$, the hazard is monotonically decreasing from γ at to zero as $t \rightarrow \infty$; when $\alpha < 1$, the hazard is also monotonically decreasing to zero as $t \rightarrow \infty$; but hazard is unbounded as t approaches zero. When $\alpha > 1$, the hazard is increasing until $t = [(\alpha - 1)/\gamma]^{1-\alpha}$, and then it decrease to zero. [27]

[27] The log-logistic regression is one of the accelerated failure time (AFT) model. In this model, the natural logarithm of the survival time $ln\ t$ is expressed as a linear function of the covariates: $ln\ t = x\beta + \varepsilon$, where x is a vector of covariates and β is a vector of regression coefficient. The Weibull regression can be expressed as AFT model or the proportional hazard rate (PH) model. In the PH model, the covariates have a multiplicative effect on the hazard function: $h(t) = h_0(t)g(x\beta) + \varepsilon$, where $h_0(t)$ is the baseline hazard function and $g(x\beta)$ is a nonnegative function of the covariates.

The hazard function indicates the probability that a person who is working up to time t, retire between time t and t+1. For example, if T is the time to retire, measured in months, then λ (35) is (approximately) the probability of retiring between months 35 and 36. This also means that the person was working up to through month 35. That is, $\lambda(35)$ is roughly the probability of retiring between months 35 to 36, conditional on working through month 35. One of difficult part in using survival analysis is to specify the hazard function. However, the Cox regression technique provides a method for estimating the parameters in a proportional hazard rate model without specifying the baseline hazard function. A proportional hazard function models comprise an important class of survival models. A proportional hazard can be expressed as follows: $\lambda(t,x) = \kappa(x)\lambda_0(t)$, where $\kappa(\cdot)>0$ is a nonnegative function of x and $\lambda_0(t) > 0$ is called baseline hazard. The baseline hazard is common to all units in the population, and is calculated when all independent variable is zero. $\kappa(\cdot)$ is parameterized as $\kappa(x) = exp\ (x\beta)$, where β is a vector of parameters. Then $\log \lambda(t,x) = x\beta + \log \lambda_0(t)$, and therefore β_j measures the semi elasticity of the hazard with respect to x_j.

This study uses HRS data from 1992 -2002, and the individuals who are still working in the 2002 data are censored. In this study, the duration is measured by time to retire: difference measured in month between January and the reported time to retire.

3. Variables

Among the important independent variables are pension type dummies, pension wealth, and pension option values. Pension wealth is expected to have positive coefficients in the retirement equation. If a worker is covered by pension, the pension coverage dummy is one, otherwise zero. The pension coverage will increase the retirement wealth, so the expected sign of coefficient is positive. If a worker has one or more DC plans, then the DC dummy equals one. If a worker has DB plans, then the DB dummy equals one. The self-reported pension types are used, since individuals are expected to respond to their beliefs although the beliefs may be incorrect. This study uses pension values provided by the HRS.

The "option value" of continued work has been used as a measure of the utility incentive to continue working. The option value model was originally developed by Stock and Wise (1990) and modified by other researchers (Coile and Gruber (2000), Gustman and Steinmeier (2001)). The option value is the difference between the lifetime utility associated with retiring at the optimal retirement date, R^*, and that associated with retirement at time t: $G_t(R^*) = \mathrm{EV}(R^*) - \mathrm{EV}(t)$. Workers should continue to work so long as the option value is positive, and should retire when the option value changes from positive to zero. Empirically, the greater the option value means the lower the probability of retirement at time t. The option value of retirement can be calculated based on assumed parameter values and used as an explanatory variable. In year t, the option value calculation for each individual who is age a is:

$$G_t(R^*) = \Sigma_{s=t}^{R^*-1} \delta^{s-t} \pi(s|t) E_t(y_s^{\gamma}) + \Sigma_{s=R^*}^{T} \delta^{s-t} \pi(s|t) E_t[kp_s(R^*)]^{\gamma}$$
$$- \Sigma_{s=t}^{T} \delta^{s-t} \pi(s|t) E_t[kp_s(R^*)]^{\gamma} \qquad (8)$$

In this expression, δ is a discount factor, γ is a parameter of relative risk aversion, $\pi(s|t)$ is the probability of someone age a in year t surviving to year s, and the expectation operator, E (.), denotes expected value of future income $\{y_s\}$ and retirement benefit streams $\{p_s(R)\}$, with the latter conditional on retirement year R. R^* is the optimal retirement date determined by considering all possible dates between t and T and selecting the one that maximizes the right-hand side of the equation. A factor k ($k > 1$) means that the added leisure during retirement increase utility, since retirement benefits are obtained without work. A value of γ ($\gamma < 1$) implies that the individual would prefer that a given present value of income and benefits be distributed evenly all years. Stock and Wise (1990) estimated the parameters of the option value model, and estimated γ and k of 0.63 and 1.25, respectively. Samwick (1998) used 0.75 for γ and 1.5 for k.

Coile and Gruber (2000) note that the major source of variation in the option value is the variation in wages. They argue that this might pose problems for the estimation of the impact of Social Security policy. To address this potential shortcoming with the option value model, they propose a "peak value," a new forward-looking measure of incentives. Peak value is comparable to the accrual, but looks forward more than just one year: Peak value calculates the difference between Social Security wealth at its maximum expected value and Social Security wealth at today's value, to measure the incentive to continued work. Since wages are not included specifically into the peak value calculation, peak value can focus on the variation from the structure of the Social Security entitlement rather than differences in wages.

$$\text{PKV}_t\,(R^*) = \Sigma_{s=R^*}^{\;T}\, \delta^{s-t}\, \pi(s|t)\, E_t\,[p_s\,(R^*)] - \Sigma_{s=t}^{\;T}\, \delta^{s-t}\, \pi(s|t)\, E_t\,[p_s\,(t)] \qquad (9)$$

Samwick (2001) shows that peak value is equivalent to the option value under a set of parameter restrictions. The first restriction is that the first term $[\Sigma_{s=t}^{\;R^*-1}\, \delta^{s-t}\, \pi(s|t)\, E_t\,(y_s^{\;\gamma})]$ in option value equation (8), pertaining to future earnings, is dropped. The present value of earnings through the optimal retirement age is asked to be included in the regression. The optimal retirement date, R^*, may change when the present value of future earnings is dropped from the option value to get peak value. The second restriction is that k equals unity, implying that there is no disutility of working relative to being retired. This restriction may be seen counterintuitive, but if peak value compares income flows only during the retirement, this assumption is admissible. The third restriction is that γ equals unity, implying that workers are indifferent to whether income and retirement benefit payments vary across years. This restriction is less critical, since the peak value calculation pertains to annuity income from Social Security and DB plans.

Gustman and Steinmeier (2001) propose the *premium value* as an alternative to option value. The well-used option value does not capture the potential of a future extra bonus on top of any current accruals. For example, the option value would increase more or less indefinitely for the DC plans, and yet these plans in general are not perceived to provide a strong incentive to retire at any particular time. For this reason they introduce a new measure of future incentives which they call premium value. The premium value is defined as the difference between the present value of the future benefit stream and the present value of a stream of benefits equal each year to the value of the basic level of accrual initially observed for the plan. To calculate this value, for each year they calculate the value of the pension and compare it to the value the pension would have if the current accruals were to continue until the future year. The premium value is the maximum of the present value of these differences. A DC plan which increases steadily in value will have zero value, since there are no future benefits that are not evident in the current accrual rate. They point that the peak value proposed by Coile and Gruber (2000) counts all increases in benefits with continued work, and thus peak value continues to increase in time as benefits are accumulated in DC plans, while the premium value does not. The peak value is the difference between the maximum pension value and the current pension value, while the premium value is the difference between then maximum pension value and the pension value that would be if current accruals remain constant. While the option value has conceptual advantages, the calculation of option value requires a specification of a utility function and estimation of many parameters. That is, the option value is expressed in utility, while the peak value and the premium value are expressed in dollar amounts. Despite their conceptual disadvantages, the peak value and the premium value are more convenient in the sense that they do not require strong assumptions regarding the form of the utility function.

The option value in this study is defined as the difference between the maximum pension values at various ages and the current pension values. This calculation assumes an interest rate of 6.3%, a wage growth of 5%, and an inflation rate of 4%.[28] The values of these rates are the intermediate long-term rates forecast by the Social Security Administration as of the mid-1990s.

The starting point to study longevity risk empirically is how to measure this risk. Longevity risk is defined as the risk that one will live beyond one's expected life span and thus run out of money. The longevity risk depends on various factors such as age, retirement time, life expectancy, consumption and wealth (including Social Security wealth and pension wealth). To measure the longevity risk, all of these factors should be considered. One way is to include these factors in the regression equation. However, simple linear combinations of the related variables may not capture the interaction effects of these factors.

This study uses the annuity equivalent wealth to consider the interaction effects of the factors that affect longevity risk. A life annuity removes the risk of outliving one's resources. Without access to annuities in retirement, a retiree should reduce his consumption level in order to ensure that he will not run out of money. Assuming a well-functioning annuity market, annuities provide for higher levels of income than one could receive in the absence of annuities, in exchange for making the receipt of this income contingent upon living. Since the value of annuity equivalent wealth depends on longevity risk, it can be used as proxy value for longevity risk. Yaari's (1965) life-cycle model without loading factors, bequests, or other non-mortality sources of uncertainty indicates that everyone has utility gains from annuitization. The magnitude of these

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[28] Pension wealth values are based on the results calculated by Bob Peticolas and Thomas Steinmeier. This data set is one of HRS researchers' contribution data set. These values are the intermediate long-term rates forecast by the Social Security Administration as of the mid -1990s.

utility gains, the annuity equivalent wealth, however, may vary greatly across individuals based on the behavioral and economic parameters that we assume. For example, more risk averse individuals will have a higher valuation of annuities than less risk averse individuals. The annuity equivalent wealth (AEW) measures the increase in utility resulting from access to fair annuities in terms of dollars. The value of increase in wealth equals the additional wealth we must give a person in the absence of annuitization to keep the person on the same expected utility curve as if we provided actuarially fair annuity markets for the individual. The annuity equivalent wealth measure captures the maximum mark-up over the actuarially fair cost that an individual would be willing to pay (Brown, 2001).

Kotlikoff and Spivak (1981) show that the percentage increase in initial wealth required to obtain the utility level with fair annuities, that is, the annuity equivalent wealth, can be calculated by solving the following equation:

$$H_0\,(MW_0) = V_0\,(W_0),$$

where M is the annuity equivalent wealth, W_0 is initial wealth, and H and V are the indirect utility functions for the no-annuity and annuity case, respectively.

Assuming that individuals exhibit the constant relative risk aversion, that is, $EU = \sum_{s=t}^{T} \pi(s\,|\,t) \frac{C_s^{1-\gamma}}{1-\gamma} \delta^{s}$, then the annuity equivalent wealth for single person can be calculated by the following formula[29] :

$$AEW = \left[\frac{\sum_{s=t}^{T} \delta^{\frac{s}{\gamma}} (1+r)^{\frac{s(1-\gamma)}{\gamma}} \pi(s\,|\,t)}{\sum_{s=t}^{T} \delta^{\frac{s}{\gamma}} (1+r)^{\frac{s(1-\gamma)}{\gamma}} \pi(s\,|\,t)^{\frac{1}{\gamma}}} \right]^{\frac{\gamma}{1-\gamma}}, \qquad (10)$$

where T is the maximum longevity or the terminal period, δ is the discount rate; $\pi(s|t)$ is the probability of someone age a in year t surviving to year s; r is the interest rate; γ is the constant relative risk-aversion parameters. As the above formula shows, for the constant relative risk aversion case the annuity equivalent wealth is independent of the initial level of wealth.

Brown (2001) improved the annuity equivalent wealth measure by incorporating the amount of wealth that is already previously annuitized by Social Security and DB plans. He added the level of the pre-annuitized wealth to the model. While it is possible to derive a solution analytically in the Kotlikoff and Spivak (1981) model, the presence of pre-existing annuities requires numerical methods. The annuity equivalent wealth should be smaller when a person has more annuitized wealth in the form of a defined benefit pension or Social Security benefits.

AEW in this study is calculated on the same assumption as in the pension value calculation and one additional assumption: R (one plus interest rate) × δ (time preference parameter) = 1. For the calculation of AEW, age, sex, the degree of relative risk aversion and the proportion of pre-annuitized wealth are used. Two methods of AEW calculation are employed: Kotlikoff and Spivak (1981), and Brown (2001). Since Brown (2001)'s method considers the proportion of pre-annuitized wealth, i.e., the effect of portion of DB pension wealth, I use this method mainly in the estimation. However, Kotlikoff and Spivak's (1981) method can calculate AEW analytically, and so is more convenient to compute. I use Kotlikoff and Spivak's AEW method for comparison with Brown's (2001) method.

The coefficient of relative risk aversion for AEW calculation is based on answers to the two subsequent survey questions on job choices (Question L14, L14a and L14b in

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[29] The notation is changed for consistency.

the first wave HRS, See Appendix 1). Based on answers to these questions, the sample may be divided into four groups. These groups can be ranked in terms of their risk aversion. Assuming that individuals have a constant relative risk aversion utility function, it is possible to put specific bounds on the value of risk aversion by solving the following inequality:

$$0.5\, U(2c) + 0.5\, U(\lambda c) > U(c),$$

where U is the utility function, c is consumption, and λ is the fraction of potential income reduction (Barsky, Juster, Kimball and Shapiro, 1997). For example, the coefficient of relative risk aversion for the group who rejected one-third, but accept one-fifth can be calculated by solving two inequalities:

$$0.5\, U(2c) + 0.5\, U(0.8c) \geq U(c) \text{ and } U(c) \geq 0.5\, U(2c) + 0.5\, U(2/3c)$$

The upper bound and the lower bound of this group is 3.76 and 2, respectively. Barsky et al. (1997) estimated the mean value of each group to be 0.7, 1.5, 2.9 and 15.8.[30] The values used here are the mean values of each group, but since the mean value of the most risk averse group seems to be too high, the coefficient of that group is changed from 15.8 to 5.0 in the manner following Brown (2001).[31]

The process to estimate the AEW value follows Brown (2001). The AEW calculation proceeds in two steps. In the first step, the individual is assumed to have access to actuarially fair, real annuity markets and to fully annuitize the starting wealth

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[30] Kimball, Sham, and Shapiro (2005) explain how to estimate the mean value of relative risk aversion in detail.

[31] Lower/ upper bound and mean value for each group

	Lower bound	Upper bound	Value used
1. Reject both 1/3 and 1/5	3.76	∞	5.0
2. Reject 1/3, accept 1/5	2.00	3.76	2.9
3. Accept 1/3, reject 1/2	1.00	2.00	1.5
4. Accept both 1/3 and 1/2	0	1.00	0.7

W_0, attaining the maximum utility V^*. The second step is to find the additional wealth ΔW, which must be given to the individual to achieve the same utility level as V^* when annuities are not available. If $V(W_0+\Delta W) = V^*$, then AEW is defined as $(W_0 + \Delta W)/W_0$.

The use of dynamic programming methods is necessary to solve for optimal consumption paths in multi-period, stochastic life-cycle model. Let $U(c_t)$ be the utility function, δ the utility discount rate, and T the maximum possible life-span of an individual. Then the consumer's problem is:

$$\underset{\{c_t\}}{Max} \quad E_t \left[\sum_{t=1}^{T-age+1} \frac{U(c_t)}{(1+\delta)^t} \right] \tag{11}$$

where the expression E_t [.] is taken over states of survival. The objective function is subject to the following constraints:

(i) W_0 given

(ii) $W_t \geq 0$ for all t,

(iii) $W_{t+1} = (W_t - C_t + S_t + A_t)(1+r)$ (12)

In these constraints, W_t is non-annuitized wealth in period t, C_t is consumption, S_t is the pre-existing annuity payment form Social Security and DB pensions, A_t is the fair annuity payment that can be purchased in annuity market. Assume that the individual has financial wealth W^*. For the case where no annuities are available, $W_0 = W^*$, and $A_t = 0$ for all t. In order to use dynamic programming techniques, it is useful to introduce a value function $V_t(W_t)$, which is defined as:

$$V_t(W_t) = \underset{\{c_t\}}{Max} \quad E_t \left[\sum_{t=1}^{T-age+1} \frac{U(c_t)}{(1+\delta)^t} \right] \tag{13}$$

subject to the constraints in equations (14). The value function at time t is the present value of expected utility evaluated along the optimal path. This value function satisfies the following recursive Bellman equations:

$$\underset{\{c_t\}}{Max}\ V_t(W_t) = \underset{\{c_t\}}{Max}\ U(c_t) + \frac{1-q_{t+1}}{1+\delta} V_{t+1}(W_{t+1}) \tag{14}$$

where q_{t+1} is the probability of dying before period t+2 conditional on surviving to period t+1, i.e., $q_{t+1} = 1 - \pi(t+2|t+1)$.[32] Numerical methods are required because of the presence of pre-existing annuities. The AEW calculation proceeds in two steps. In the first step, the individual is assumed to have access to actuarially fair, real annuity markets and to fully annuitize the starting wealth W_0, attaining the maximum utility V^*. The second step is to find the additional wealth ΔW, which must be given to the individual to achieve the same utility level as V^* when annuities are not available. That is, if $V(W^*+\Delta W|\ A_t=0)$ = V*, then AEW is defined as $(W^* + \Delta W)/W^*$.

Health and health insurance related variables are reported to have significant effects on retirement decisions. If reported respondent's health is fair or poor, the poor health dummy is one, otherwise zero. A healthy worker tends to retire later, and so the expected sign on this dummy is positive. Many researchers find that employer-provided health insurance has job lock effect. The presence of the health insurance is expected to delay retirement, whereas a retiree health insurance program would induce early retirement.

Other control variables include demographic variables (age, education, sex, marital status, number of children, and a dummy variable for young children age 17 or

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[32] Life table of year 2000 from Social Security Administration is used.

less), health and health insurance variables, and wealth and income related variables. Age will increase the probability of retirement, and so a positive coefficient is expected. Although the effect of education on retirement is not as clear as age, previous studies show that education has delaying effects on retirement. If education influences the wage or income, then the increased wage or income will explain the negative coefficient. The effect of gender is not clear. Married people were estimated to retire later in some studies (i.e. Samwick, 1998a). The marriage status dummy is one when a respondent is currently married. Divorced or widowed are classified into zero. Since parents have to work more to support their children, but parents can rely on their children during the retirement period, the effect of number of children is not clear. Young children are expected to delay the retirement timing of their parents. Dummy variables for industry and occupation are also included in the regressions. Two indicator variables are added to control for the bequest motive: High probabilities of leaving bequest and the high importance of bequest. A dummy variable myopic equals one if the individual states that his or her time horizon for financial planning is one year or less, and zero otherwise.

IV. Results

1. Descriptive Statistics

This section presents the estimation results, starting with the descriptive statistics. Table 1 compares means and standard deviations of the variables of workers with different types of pensions for the sub-samples of HRS participants used in this study. The average age of survey participants in the sample is 55.9 years, and females comprise 50.8 percent of the sample population. The average education level is 12.3 years (high school diploma), with a minimum of zero year and a maximum of 17 years. Over half the workers (63.7 percent) reported that they have an employer-provided retirement plans: 49.6 percent are covered by only the DB plans; 24.6 percent are covered by only the DC plans, and 25.8 percent have both DB plans and DC plans.[33]

The summary statistics indicate that workers with different types of retirement plans have important differences in the level of pension wealth, job characteristics and AEW value. First, pension wealth differs across plans. Workers with both types of pensions have the highest value of pension wealth, with a mean value of $148,000 in 1992. The means value of pension wealth in DB plans is $130,000. This figure is two times higher than the value of DC pension wealth ($48,000). Second, Job tenure of workers with DB plans is longer than that of workers with DC plans (16.9 years and 13.6 years, respectively). Of those reporting DB only coverage, about 38.8 percent are in professional or related services or public administration.[34] In addition, for 1992 the

[33] This figure is somewhat different from those based on company data, since the HRS did not obtain the data on many of respondents who have pension plans and many of respondents misunderstood the nature of their own pension plans.

[34] Friedberg and Webb (2003) reported that 55 percent of individuals with only DB plans are employed in professional or related services or public administration, however their sample does not include self-employed.

average earnings of workers with DC plans are $29,000, which is approximately 10 percent higher than the average earnings of $26,000 for workers with DB plans. Finally, on average, individuals in the sample have an annuity equivalent wealth of 1.30, implying that they would be indifferent between $1 of annuitized wealth and $1.30 of non-annuitized wealth. Individuals with DC have an AEW value of 1.32. This value is significantly higher the average AEW value of 1.26 for individuals with DB plans. This difference reflects the intuition that DB plans provide a life annuity, and thus reduce longevity risk.

Table 2 shows the change in self-reported retirement status. In the first year, 21.0 percent of individuals considered themselves retired, and during the following ten years, more than half of individuals retired by the sixth wave of the survey. Among 6,578 workers working full time in the first wave, 25.5 percent of workers still consider themselves not retired in the sixth wave of the survey.

2. Regression Analysis

Table 3 shows the results of the expected retirement year regression. This OLS regression uses the self-reported pension types, since the dependent variable is the expected retirement year, and the retirement decision depends much on individuals' perception. In regression 1 (Table 3, column 1), I use age, gender, a relative risk aversion factor and the proportion of pre-annuitized wealth as explanatory variables. In regression 2 (Table 3, column 2), I include a longevity risk measure that is a function of these variables. I find that workers with DB plans expect to retire later than workers with DC plans. Interestingly, workers with DC plans expect to retire later than workers without pensions. This may appear counter-intuitive; however, considering that the assets in DC plans cannot be withdrawn penalty-free until age 59½, this result may be reasonable.[35] The pension option value, measured as the difference between the pension value in 1992 and the maximum pension value among pension values at different ages, is not significant. Pension wealth is also insignificant. Both variables, though, have the expected sign. Non-pension wealth decreases the retirement age at which individuals expect to retire. Earnings are insignificant in the regression of expected retirement year.

The coefficient of age is negative and significant, indicating that a one year older individual expects to retire early by about eight months. Females expect to retire earlier than males by nine months. The relative risk aversion measure is not significant, but pre-annuitized wealth reduces the expected age of retirement. Specifically, a ten percent point increase in pre-annuitized wealth leads to a two month decrease in expected age of retirement, implying that workers with more wealth accumulated in DB plans expect to retire earlier. As expected, individuals who think they have a low probability of living after age 75 expect to retire early by approximately six months. Since late retirement reduces the period during which individuals receive pension benefits, persons who do not expect to live long prefer to retire early. Bad health as measured by self-estimation also has a negative impact on the expected age of retirement. The effects of pension wealth and pension option values are consistent with previous literature, and the effect of longevity risk is also compatible with predictions, even though there was no previous empirical research testing the effect of longevity risk.

Employer provided health insurance has a positive effect on the expected retirement year, since the loss of health insurance increases the cost of retirement. The coefficient on retiree health insurance is negative. Individuals with children 17 years old

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[35] The additional tax on early distributions does not apply in the case of death, disability, or termination of employment after age 55. Exceptions also are granted for some specified cases (Allen et al. (2003), pp.506-507).

or younger expect to retire about a half year later. However, the coefficient on the number of children is not significant. Persons who believe they have a high probability of high bequests expect to retire early. The value that individuals put on the bequest is not significant. Highly educated and white persons expect to retire later, while married persons, U.S.-born persons, and myopic persons expect to retire early. Self-employed, skilled workers and semi-skilled workers expected to retire later, while long tenured workers expect to retire early.

The second set of results in table 3 (regression 2) incorporates the longevity risk measure (AEW). This regression leaves out gender, the risk aversion measure and the proportion of pre-annuitized wealth because these variables are used to calculate the AEW. Age is added to the regression to control for the effect of age separately. The coefficient of AEW is significant and positive, implying that persons with higher longevity risk expect to retire later. A ten percent point increase in AEW increases the expected age of retirement by five months. The large coefficient on AEW should be interpreted with consideration of the range of AEW. The range of AEW in the sample is approximately 50%, so the effect of AEW could range up to two years. The elasticity[36] at mean value of AEW is 0.887, implying that 10% increase in AEW from its mean value (1.30) will induce 8.87% or 8.2 months ((= 5.29*1.30*.1*12)) delay in expected time to retire or expected retirement age (mean value of expected retirement age 63.4).

To examine the different effects of DB plans and DC plans, separate regressions are conducted on the two different types of pensions. The results of the regressions are located in table 4. Regression 1 shows that DC plans increase the retirement age by 0.7 year compared to DB plans. The AEW in the DB plans sample (regression 2) is less significant, reflecting that the DB plans provide a life annuity, and thus reduce longevity

[36] Elasticity gives the percentage change in the dependent variable that results from a 1% change in the explanatory variable.

risk. The coefficient of the dummy variable for a perceived low probability of living past age 75 is negative, implying that person who expects to have a short life expectancy retires earlier to collect more pension benefits. In the DC plan group, the longevity risk variable has a significantly positive effect on the expected retirement age. The longevity risk matters more in DC plans. The dummy variable for low probability of living over age 75 is insignificant.

Table 5 presents the results of the probit regression model where the self reported retirement status is the dependent variable. When workers reported they retired in 1992, the dependent variable is one, and it is zero otherwise. A positive coefficient in this regression indicates a higher probability of retirement. Overall, the probit regressions confirm the findings of the OLS regressions. DC plans decrease the probability of retirement, while DB plans do not affect the probability of retirement. Having a DC plan reduces the probability of retirement relative to not having a pension or having DB plans. The pension option value significantly decreases the probability of retirement, suggesting that the value of pension option plays a role in an individual's decision to retire. Moreover, pension wealth has significantly positive impacts on the probability of retirement, while non-pension wealth is not significant. Considering that pension wealth in DC plans is about half of the pension wealth in DB plans, workers with DC plans retire later than workers with DB plans. The probit analysis confirms the hypothesis that pension wealth increases the probability of retirement and the hypothesis that lager pension option value decreases the probability of retirement. High earnings significantly reduce the probability of retirement.[37]

[37] Earnings information on retired workers is not available in the public data set. Accordingly, in this probit estimation, household income is used as a proxy for earnings. The earnings from an individual's last job may not be suitable, since the timing of retirement is so diverse. For the same reason, tenure, industry, and occupation are obtained from each individual's occupation of the longest reported tenure.

Longevity risk has a negative impact on the probability of retirement, consistent with expectation. A ten percentage increase in AEW increases the odds of delaying retirement by 1.5 percent. The negative coefficient of pre-annuitized wealth, however, is inconsistent with expectation. A self-perceived low probability of living past age 75 has a positive effect on retirement probability. Risk averse persons tend to retire later. Poor health status increases the probability of retirement. Age is significantly and positively related to the probability of retirement.

Employer provided health insurance has a negative effect on the probability of retirement, which is consistent with the result of the expected retirement age regression. Retiree health insurance increases the probability of retirement. The number of children an individual has increases the retirement probability. Children can also reduce longevity risk by providing financial or other support during the retirement period, so the positive coefficient on the number of children may be reasonable. Young children reduce the probability of retirement, implying that parents tend to delay their retirement until their children become independent. A dummy variable for a high bequest probability has a positive sign, indicating that an individual's value of bequest has an effect on the retirement decision. Among the demographic variables, the number of years of education, the number of tenure, and being born in the U.S. increase the probability of retirement.

Table 6 provides the estimation results of the multinomial logit regressions. The dependent variable is self-reported retirement status. Full retirement has the value of two, partial retirement the value of one, and no retirement equals zero. A positive coefficient in this multinomial logit regression indicates a higher probability of each type of retirement. The presence of DC plans has a negative effect on the probability of full retirement. Specifically, DC plans reduce the log-odds between full retirement status and working status by 0.578. The pension option value has a negative effect on the probability of partial and full retirement. Pension wealth has a positive effect on the probability of full retirement, while non-pension wealth is significant in the partial retirement regression. High earnings reduce the probability of retirement.

A perceived low probability of survival past age 75 has a positive effect on the probability of retirement. Pre-annuitized wealth has a negative coefficient contrary to what is predicted by the theoretical model, but it is insignificant. In the second specification, Longevity risk has a negative effect on the probability of full retirement. Poor health condition increases the probability of full retirement.

Health insurance and health status have the same results as probit specifications. Employer provided health insurance decreases the probability of full retirement, while retiree health insurance increases the probability of full retirement as predicted. The number of children increases the probability of partial retirement. Young children reduce the probability of the partial retirement. Interestingly, the variables related to children are insignificant in the full retirement regression. A dummy variable for bequest importance has a negative coefficient, suggesting that those who place a high value on bequests try to accumulate wealth by postponing retirement. A dummy variable for a high bequest probability has a positive sign. The positive sign on high bequest probability indicates that individuals who think they accumulate enough wealth can retire earlier. Individuals who have a relatively high education and individuals who were born in the U.S. have a higher probability of full retirement. The myopic dummy variable has a positive effect on retirement probability, i.e., those who have short-term view in financial planning tend to retire early. Individuals who have long job tenure also have a higher probability of full retirement.

Table 7 shows the results of the probit regressions in which workers are defined as retired when they reported they worked in the first wave but retired in the following wave. The samples are restricted to the individuals who were reported as working in the first wave. The coefficient of DB pension dummy variable is positive. Pension option value has a negative effect on the probability of retirement while pension wealth has a positive effect on the probability of retirement. The coefficient of earnings is negative and significant. Risk aversion reduces the probability of retirement, but pre-annuitized wealth increases the probability of retirement. The combined longevity risk variable, AEW, is not significant. Poor health increases the probability of retirement.

Health insurance has the same effects as before. Employer provided health insurance reduces the probability of retirement, while a retiree health insurance program increases it. Young children reduce the probability of retirement. Variables related to bequest motives are not significant in these analyses. Individuals who were born in the U.S. and individuals who have longer tenure have a higher full retirement probability.

Table 8 repeats the multinomial logit regression analysis with the sample of persons who were working in the first wave. The dependent variable equals one if an individual was working in the first wave but retired in the following wave. DB plans increase the probability of full retirement. Pension option value decreases the probability of retirement. Pension wealth increases the probability of retirement, and non-pension wealth also has a positive effect on the full retirement probability. High earnings reduce the probability of retirement. A relatively higher level of risk aversion reduces the probability of retirement and pre-annuitized wealth increases the probability of retirement. The combined longevity risk variable, AEW, is not significant. The self-estimated probability of living after age 75 is also not significant.

Health insurance has a similar effect as in the previous analyses. Employer provided health insurance reduces the probability of retirement, while retiree health insurance increases the probability of retirement. Having young children in the family reduces the probability of retirement. The other bequest motive variables are not significant. Self-employed workers and worker born in the U.S. retire later, and workers with long tenure retire earlier.

Table 9 shows the results from the survival analysis. Here the duration is the time to retire, in months. Although the duration is rounded to the nearest month, it is treated as a continuous variable with Weibull distribution. The focus is on how certain covariates affect the hazard function for retirement, and also whether there is positive or negative duration dependence. The variables – pension wealth, pension option value, and AEW are of particular interest. In the duration analysis, the dependent variable is time to retire measured by month. This analysis is similar to the OLS regression (Table3) in the sense that both analyses use the time to retirement. But time to retire in OLS is the expected one and is not censored, while time to retire in duration analysis is actual one and right censored. Time to retire in the duration analysis is measured by month, so this variable can capture the variations in retirement in the sample better than the time to retire in OLS analysis measured in year.

The hazard function with Weibull distribution is $\lambda(t) = \gamma\alpha t^{\alpha\text{-}1}$. The estimate of α is 1.073 and standard error of α (.0224) leads to rejection of the null hypothesis that α =1, implying that there is positive duration dependence, conditional on covariates. This means that, for a particular working person, the instantaneous rate of retiring increases with the length of time in working. After 50 months, an individual is 1.125 times more likely to retire per month than after ten months ($(50/10)^{1.073\text{-}1}$). Based on common sense on retirement, we would expect this positive duration dependency. However, considering that retirement rates are higher around a specific age, i.e., age 60-62, the curved hazard function with log-logistic distribution, lognormal distribution or general gamma distribution may be better than monotonically increasing hazard function. Because average age of the sample is 56, the peaks of hazard function from lognormal or generalized gamma distribution are too early (Figure 4). Thereby, log-logistic hazard function seems to be better than hazard functions with lognormal or generalized gamma distribution.

A generalized gamma model is useful to choose the preferred model (Stata Reference P-St, p.445). The first step is to fit a generalized gamma model, and the second step is to test the hypothesis that k = 0 (test for the appropriateness of the lognormal) and test the hypothesis that $\kappa = 1$ (test for the appropriateness of the weibull), where κ is the parameter that is estimated in a generalized gamma model. The hypothesis that $\kappa = 0$ is rejected at p = 0.00 level, suggesting that the lognormal is perhaps not an adequate model. The Wald test for $\kappa = 1$ is $[(0.06285-1)/0.0686]^2 = 29.32$, which yield a $\chi^2(1)$ significance of 0.00, providing support for rejecting the Weibull model. To select an appropriate model, it is also common to use the Akaike information criterion (AIC). AIC penalizes each log likelihood to reflect the number of being estimated in a particular model and then comparing them. The AIC can be defined as

$$\text{AIC} = -2\,(\text{log likelihood}) + 2(c + p + 1)$$

where c is the number of model covariates and p is the number of model-specific ancillary parameters. Although the best-fitting model is the one with the largest log-likelihood, the preferred model is the one with the smallest AIC value. In this study, log-logistic model has the smaller AIC than Weibull model (7511.6 and 7556.0, respectively).[38]

The second column in Table 9 shows the estimation results of duration analysis assuming loglogistic distribution. A one percent increase in the pension option value reduces the hazard ratio by .04 percent, and the effect is statistically significant. A one percent increase in pension wealth decreases the duration by .05 percent, and the effect is also statistically significant. The effects of pension option value and pension wealth are predicted by the model. A one percent increase in earnings increases the duration by 0.026 percent. A ten percent increase in the longevity risk measured by AEW deceases

[38] This study compares AIC from other hazard functions such as log-normal model, generalized gamma model, Gompertz model, and exponential model.

the duration by 7.8 percent (=100*[*exp*(0.7539*0.1)-1]).[39] The duration of a one-year older person is 17.4 percent shorter. The duration of the person with low probability of living after 75 is 11.3 percent shorter than that of someone with high or average probability of living after 75. The duration is 83.4 percent (=100*[*exp*(0.6069)-1]) shorter for someone with poor health than someone with good health.

The coefficients of health insurance show the expected signs. Federal health insurance or retiree insurance decreases the duration by 45.3 percent and 33.5 percent, respectively. On the contrary, employer provided health insurance increases the duration by 36.5 percent. The duration for a person who has children younger than 17 is 25.4 percent larger than a person without young children. The duration for whites is about 10.6 % shorter than non-white people's.

The column 3 and 4 in table 9 show the results of Weibull regression and the Cox regression.[40] The assumption that the hazard function is a specific distribution may be too restricted, even though in this study the parameters follow the predictions. A Cox regression provides more flexible alternatives in the sense that the estimation in a Cox regression is performed without any assumptions on the distribution of the hazard function. The result is also similar to the log-logistic regression results. For example, a one-year increase in age increases the baseline hazard rate by 18 percent.

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[39] For large coefficients, we should exponentiate and subtract unity to obtain the proportionate change (Wooldridge, 2002, p.697).

[40] Cox regression provides only the hazard ratio regression. The coefficients should have opposite sign to the other specifications in Table 9.

3. Robustness Check

A number of robustness checks are performed on the regressions.[41] First, the lump-sum benefit from the DC plans can be annuitized at retirement. To check the potential effect of annuitization, a dummy variable for the willingness to annuitize the lump-sum benefit from the DC plans is added to the basic regression. Table 10 shows that the results are robust. In addition, the willingness to annuitize delays the expected retirement year or reduces the retirement probability.

Second, pension value or option values are calculated with fixed interest rates. When the interest assumption changes, pension wealth and option value change. Pension value is calculated with the following assumption; Scenario #2: Interest rate is 6.0%, wage growth is 5%, and inflation rate is 4%; Scenario #3: Interest rate is 6.5%, wage growth is 5%, and inflation rate is 4%; and Base scenario: Interest rate is 6.3%, wage growth is 5%, and inflation rate is 4%. Pension value in scenario #2 becomes lager than in the base scenario since the interest rate in scenario #2 is lower than in base scenario. The mean value of pension wealth is \$120,739 (basic scenario), \$121,917 (scenario #2), and \$120, 072 (scenario #3). However, Table 11 shows that the effects on retirement are not changed.

Summary of scenarios (Changes in interest rate)

	Interest Rate	Wage Growth	Inflation Rate
Scenario #1	6.30%	5%	4%
Scenario #2	6.00%	5%	4%
Scenario #3	6.50%	5%	4%

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[41] In addition to robustness checks described here, to deal with the impact of potential heterogeneity on results, the robust regression is compared with the basic regression. The quantitative results do not change much and qualitative results are unchanged.

Finally, to this point a homogenous utility discount rate is assumed. When individuals have different discount rates, the AEW value will change. The same interest rate as in the previous analysis is used in this analysis. In sum, the effects of different discount values are also checked and the analysis shows that the basic results change little. Different discount values are assigned according to Samwick (1998b). Samwick estimates the distribution of rate of time preference using the wealth data from the Survey of Consumer Finance 1992 and a flexible life-cycle model of consumption under income uncertainty. His intuition is that high discounters will save less than low discounters, and so it is possible to estimate the discount values from the wealth. According to his estimation, the median value of discount rate is 4.28 % per year for the case in which relative risk aversion equals 2, and initial wealth is one times the individual's permanent income. In this study, I divide sample into four groups by the ratio of wealth to household incomes, and assign four different discount rates, 0, 4.28%, 8.78%, 13.17%, from high wealth group to low wealth group, respectively. These discount values are based on Samwick's estimation for the case in which relative risk aversion equals two, and initial wealth is one times of individual's permanent income. The mean value of discount values is higher than the discount value used in this study. The assumption that the interest rate equals the inverse of discount value does not hold. For the case in which the inverse discount value times interest rate is less than one, the model in this study does not always predict that a greater longevity risk induces workers to retire later.

As Table 12 shows, the longevity risk measure, AEW, has the expected sign in the OLS regression and the coefficient is significant. In the probit regression, however, AEW is not significant, although the sign is as expected. The non-significant sign in the probit analysis implies that high discounters put a high value on present consumption, and do not care much about future consumption, or longevity risk. The reduced interest in longevity risk could explain the insignificant coefficient on AEW. The significance of

AEW is restored when the highest discount group is excluded from the analysis as shown the third column in the Table 12. The prediction of model can hold even when the discount rate is a little higher than the interest rate.

V. Conclusion

This study examines why workers with DC plans retire later than those who have DB plans and concludes that the reasons of late retirement of workers with DC plans are less pension wealth, lower pension option values and greater longevity risk in DC plans. It is important to understand the reason of later retirement of workers with DC plans, since the proportion of DC plans in retirement pension plans have increased and are expected to keep increasing. Many of researchers have found that financial incentive in DB plans induces workers to retire at specific age, i.e., at normal retirement age, since the pension benefit will decrease after that age. By analogy, many researchers suggest that lacks of financial incentive in DC plans can explain the later retirement. In DC plans, workers do not lose pension benefits even though they will keep working in old ages. Friedberg and Webb (2004) find the evidence for the effect of differences in financial incentives between DB plans and DC plans on retirement. The difference in financial incentives, however, is not the only reason of later retirement of workers with DC plans. This study explores risk factors in pension plans in addition to pension wealth and financial incentives. Workers with DC plans will have more longevity risk, since DB plans provide annuitized benefits, while DC plans provide the lump-sum benefit. The additional longevity risk requires workers to save more or to work longer or both.

The model in this study extends the lifecycle consumption model by adding the risk factors in pension benefits. This extension will be one of main contributions of this study to pension literature. The model predicts that increased risk will induce workers to retire later. In addition, pension wealth will induce early retirement, while the option value used to measure financial incentives will induce later retirement. This study uses annuity equivalent wealth as proxy for longevity risk. The use of AEW may be a way to integrate the effect of various factors such as age, sex, degree of risk aversion, and the proportion of annuitized wealth on longevity risk.

The regression results support the predictions based on the theoretical model. The results reveal that retirement wealth prompts workers to retire early. Since pension wealth in DC plans is less than pension wealth in DB plans, DC plans have a delaying effect on retirement. The pension option value has a negative effect on the probability of retirement. DB plans have a large option value before normal retirement age compared to DC plans. The option value for DB plans, however, may be negative after normal retirement age, and thus the incentive for retirement becomes strong. Finally, the results show that longevity risk has a delaying effect on retirement. The fact that the measure of longevity risk is more significant in the DC sample implies that longevity risk impacts workers with DC plans more than it does workers with DB plans.

Considering that the delayed retirement in DC plans is not only the result of individual choice but also the result of other factors such as longevity risk, policy makers should consider the impacts of these factors in pension policies since late retirement may be involuntary. The absence of financial incentives for retirement in DC plans can be interpreted as the absence of a constraint in a worker's utility maximization problem. The lack of a constraint in DC plans can be utility increasing, in the sense that workers with DC plans do not have to consider the decrease in pension benefits that bothers workers with DB plans after specific age. Longevity risk, however, can be an additional constraint on utility maximization, since workers with DC plans have to consider increased longevity risk compared to workers with DB plans. Late retirement due to longevity risk can be utility decreasing. Pension policies that encourage DC plans should include a compensating mechanism for longevity risk and other risk factors.

Policy makers and researchers should compare the pension benefits in DC plans and in DB plans with annuity equivalent wealth rather than simple discounted present value. The longevity risk may be reduced if the annuity benefit is set as a default option. The same or more efforts to secure the pension benefit after retirement should be put as those to secure the accumulation of pension wealth before retirements, since the old retirees may not so smart as they were before retirement.

The results of this study have some implications for the current debate over Social Security reform. It is generally accepted that current social security system cannot be sustained without reforming. If Social Security benefit decreases because of the budget deficit, then the reduction will increase additional longevity risk. If Social Security is partially privatized, and the accumulation in personal accounts is not linked to annuitization similar to the current Social Security benefit, then those changes will also bring additional longevity risk. If U.S. government reforms Social Security toward increasing longevity risk like above examples, it should incorporate a mechanism that ameliorates longevity risk so that privatization does not decrease utility.

The intuition of this study can be applied to other topics. The longevity risk in DC plans may impact individual's savings. The risk factors in pension types may also affect workers' portfolio choice. This study considers only longevity risk, but the model in this study can incorporate other risk factors, such as investment risk in DC plans after retirement. The results of this study could be strengthened if earning history data is provided, since earning history data provides the flexibility needed for pension value calculation as well as for some variables such as Social Security wealth.

References

Allen, Everett T., Joseph J. Melone, Jerry S. Rosenbloom, Dennis F. Mahoney, 2003. *Pension Planning*: *Pension, Profit Sharing, and Other Deferred Compensation Plans*, 9th ed., McGraw-Hill Irwin.

Anderson, Patricia M, Alan L. Gustman and Thomas L. Steinmeier, 1999. "Trends in Male Labor Force Participation and Retirement: Some Evidence on the Role of Pensions and Social Security in the 1970s and 1980s," *Journal of Labor Economics*, Vol.17, No.4, pp.757-783.

Bajtelsmit, Vickie L., and Jack L. VanDerhei, 1998. "Risk Aversion and Pension Investment Choices," in *Positioning Pensions for the Twenty-First Century*, edited by Michael S. Gordon, Olivia S. Mitchell, and Marc M.Twinney. University of Pennsylvania Press (Philadelphia, Pennsylvania), pp. 45-66.

Barsky, Robert B., Thomas F. Juster, Miles S. Kimball and Mattew D. Shapiro, 1997. "Preference Parameters and Behavioral Heterogeneity: An Experimental Approach in the Health and Retirement Study" *Quarterly Journal of Economics*, Vol. 112, No.2, pp.537-579.

Blank, Emily C., 1999. "Pension Type and Retirement Wealth" *Industrial Relations*, Vol. 38, No.1, pp.1-10.

Blau David M. and Donna B. Gilleske, 2003. "The Role of Retiree Health Insurance in the Employment Behavior of Older Men," NBER working paper 10100.

Bloom, David E., David Canning, and Bryan Graham, 2003. "Longevity and Life-cycle Savings" *Scandinavian Journal of Economics*, Vol.105, No.3, pp. 319-338.

Bodie, Zvi, Alan J. Marcus, and Robert C. Merton, 1988. "Defined Benefit versus Defined Contribution Pension Plans: What are the Real Trade-offs?" in Zvi

Bodie, John B. Shoven, and David A. Wise, eds., *Pensions in the U.S. Economy*, University of Chicago Press, pp. 139 -162.

Brown, Jeffrey R., 2000. “How Should We Insure Longevity Risk in Pension and Social Security?” *An Issue Brief*, Vol.4, Center for Retirement Research.

Brown, Jeffrey R., 2001. “Private Pensions, Mortality Risk, and the Decision to Annuitize,” *Journal of Public Economics*, Vol.82, pp.29-62.

Bruce, Neil, 2001. *Public Finance and the American Economy*, 2nd ed., Addison Wesley.

Buchmueller, Thomas C. and Robert G. Valletta, 1998. “The Effect of Health Insurance on Married Female Labor Supply” *The Journal of Human Resources*, Vol. 34, No.1, pp. 42-70.

Chan, Sewin and Ann Huff Stevens, 2004. “Do Changes Incentives Affect Retirement? A Longitudinal Study of Subjective Retirement Expectations” *Journal of Public Economics*, Vol.88, pp1307-1333.

Cheng, Ing-Haw and Erich French, 2000. “The Effect of Stock Market Run Up on Labor Market” *Economic Perspectives*, Vol. 24, No. 4, Federal Reserve Bank of Chicago.

Coile, Courtney and Jonathan Gruber, 2000. “Social Security and Retirement,” NBER working paper 7830.

Coile, Courtney and Jonathan Gruber, 2004. “The Effect of Social Security on Retirement in the United States,” in Jonathan Gruber and David A. Wise ed. *Social Security and Retirement around the World*, The University of Chicago Press, 2004.

Coile, Courtney and Jonathan Gruber, 2004. “The Bulls, Bears, and Retirement Behavior,” NBER working paper 10799.

Coronado, Julia Lynn and Maria Perozek, 2003. "Wealth Effects and the Consumption of Leisure: Retirement Decisions During the Stock Market Boom of the 1990s", Federal Reserve Board.

Diamond, Peter and Jonathan Gruber, 1999. "Social Security and Retirement in the United States," in Jonathan Gruber and David A. Wise ed. *Social Security and Retirement around the World*, The University of Chicago Press, 1999.

Dwyer, Debra S. and Olivia S. Mitchell, 1995. "Health Problems as Determinants of Retirement: Are Self-rated Measures endogenous," *Journal of Health Economics*, Vol. 18, pp. 173-193.

Even, William E. and David A. Macpherson, 1998. "The Impact of Rising 401(k) Pension Coverage on Future Pension Income," Working paper. (www.garnet.acns.fsu.edu)

Feldstein, Martin and Jeffrey B. Liebman, 2001. "Social security," NBER working paper 8451.

Friedberg, Leora and Anthony Webb, 2000. "The Impact of 401(k) Plans on Retirement," University of California, San Diego, Discussion paper 2000-30.

Friedberg, Leora and Anthony Webb, 2003. "Retirement and the Evolution of Pension Structure," NBER working paper 9999.

Green, William, 2003. *Econometric Analysis*, 5th edition. Prentice Hall.

Gruber, Jonathan and Brigitte C. Madrian, 1994. "Health-Insurance Availability and Retirement Decision" *American Economic Review*, Vol. 85, No.4, pp. 934-948.

Gustman, Alan L. and Thomas L. Steinmeier, 1986. "A Structural Retirement Model," *Econometrica,* Vol. 54, No.3, pp.555-584.

Gustman, Alan L. and Thomas L. Steinmeier, 2001. "Retirement and Wealth," NBER Working Paper No. 8229.

Gustman, Alan L. and Thomas L. Steinmeier, 2002. "Retirement and the Stock Market Bubble," NBER Working Paper No. 9404.

Gustman, Alan L., Olivia S. Mitchell, and Thomas L. Steinmeier, 1986. "The Role of Pensions in the Labor Market: A Survey of the Literature," *Industrial and Labor Relations Review*, Vol. 47, No.3, pp. 417-438.

Gustman, Alan L., Olivia S. Mitchell, and Thomas L. Steinmeier, 1995. "Retirement Measures in the Health and Retirement Study," *The Journal of Human Resources*, Vol. 30, Supplement, pp. S57-S83.

Gustman, Alan L., Olivia S. Mitchell, Andrew A. Samwick, and Thomas L. Steinmeier, 1997. "Pension and Social Security Wealth in the Health and Retirement Study," NBER Working Paper No. 5912.

Hausman, Jerry A., David A. Wise, 1985. "Social Security, Health Status, and Retirement," in *Pensions, Labor, and Individual Choice*, edited by David A. Wise. University of Chicago Press, pp.159-191.

Holtz-Eakin, Douglas, David Joulfaian, and Harvey S. Rosen, 1993. "The Carnegie Conjecture: Some Empirical Evidence," *The Quarterly Journal of Economics* 102 (2): 413-435.

Hurd, Michael D. and James P. Smith, 2001. "Anticipated and Actual Bequests," in *Themes in the Economics of Aging*, edited by David A. Wise University of Chicago Press.

Hurd, Michael and James Smith, 2002. "The Effects of Subjective Survival on Retirement and Social Security Claiming," Michigan Retirement Research Center Working Paper WP 2002-021.

Imbens, Guido W., Donald B. Rubin, and Bruce I. Sacerdote, 2001. "Estimating the Effect of Unearned Income on Labor Earnings, Savings, and Consumption: Evidence from a Survey of Lottery Players," *American Economic Review*, Vol. 91, No. 4, pp.778-794.

Joulfaian, David and Mark Wilhelm, 1994. "Inheritance and Labor Supply," *The Journal of Human Resources*, Vol. 29, No. 4, pp.205-1234.

Kapur, Kanika, 1998. "The Impact of Health on Job Mobility: A measure of Job Lock," *Industrial and Labor Relations Review*, Vol. 51, No.2, pp. 282-298.

Kaufman, Bruce E., and Julie Hotchkiss, 2000. *The Economics of Labor Markets*, 5th ed., Prentice Harcourt (Orlando, FL).

Kezdi, Gabor and Purvi Sevak, 2004. "Economic Adjustment of Recent Retirees to Adverse Wealth Shocks," Michigan Retirement Research Center, Working Paper #2004-75.

Kimball, Miles S. and Matthew D. Shapiro, 1995. "Estimating a Cardinal Attribute from Ordered Categorical Responses Subject to Noise," University of Michigan working paper.

Kimball, Miles S., Claudia R. Sham, and Matthew D. Shapiro, 2005. "Using Survey-Based Risk Tolerance," ISER working paper.

King, M.A. and L-D. L. Dicks-Mireaux, 1982. "Asset Holdings and the Life Cycle," *The Economic Journal*, Vol. 29, pp. 247-267.

Kotlikoff, Laurence J., and David A. Wise, 1987. "The Incentive Effects of Private Pension Plans," in *Issues in Pension Economics*, edited by Zvi Bodie, John B. Shoven, and David A. Wise. University of Chicago Press, pp.283-339.

Kotlikoff, Laurence J., and Avia Spivak, 1981. "The Family as an Incomplete Annuities Market," *Journal of Political Economy*, Vol. 89, pp. 372-391.

Krueger, Alan B. and Jorn-Steffen Pischke, 1992. "The Effect of Social Security on Labor Supply: A Cohort Analysis of the Notch Generation," *Journal of Labor Economics*, Vol.10, No. 4, pp. 412-437.

Lazear, Edward P., 1990. "Pensions and Defined Benefits as Strategic Compensation," *Industrial Relations*, Vol.29, No.2, pp. 263-280.

Lazear, Edward P., 1995. *Personnel Economics*, The MIT Press, Cambridge, MA.

Lazear, Edward P., 1998. *Personnel Economics for Managers*, John Wiley & Sons, Inc.

Lazear, Edward P., 1999. "Personnel Economics: Past Lessons and Future Directions," *Journal of Labor Economics*, pp. 199-236.

Lazear, Edward P. and Rober L. Moore, 1988. "Pensions and Turnover," in *Pensions in the U.S. Economy*, edited by Zvi Bodie, John B. Shoven, and David A. Wise. University of Chicago Press, 163-188.

Madrian, Brigitte C., 1994. "Employment-Based Health Insurance and Job Mobility: Is There Evidence of Job-Lock?" *Quarterly Journal of Economics*, Vol. 109, No.1, pp. 27-54.

Mankiw, N. Gregory, 1999. *Macroeconomics*, 4th edition, Worth Publishers.

McGill, Dan M., Kyle N. Brown, John J. Haley, and Sylvester J. Schieber, 2005. *Fundamentals of Private Pensions*, 8th edition, Oxford University Press.

Mitchell, Olivia S. and Gary S. Fields, 1984. "The Economics of Retirement Behavior," *Journal of Labor Economics*, Vol.2, No.1, pp.84-105.

Mitchell, Olivia S., James M. Poterba, Mark J. Warshawsky and Jeffrey Brown, 1999. "New Evidence on the Money's Worth of Individual Annuities," *American Economic Review*, Vol.89, No.5, pp.1299-1318.

Moore, James F. and Olivia S. Mitchell, 2000. "Projected Retirement Wealth and Saving Adequacy," in *Forecasting Retirement Needs and Retirement Wealth*, edited by Olivia S. Mitchell, P. Brett Hammond, and Anna M. Rappaport. University of Pennsylvania Press, pp.68-94.

Munnell, Alicia H., Kevin E. Cahill, and Natalia A. Jivan, 2003. "How Has the Shift to 401(k)s Affect the Retirement Age," *An Issue Brief*, Vol.13, Center For Retirement Research.

Munnell, Alicia, Annika Sunden, Mauricio Soto, and Catherine Taylor, 2003. "The Impact of Defined Contribution Plans on Bequests," in *Death and Dollars*, edited by Alicia Munnell and Annika Sunden. Brooks Institution Press.

Nishiyama, Shinichi and Kent Smetters, 2005. "Does Social Security Privatization Produce Efficiency Gain," Congressional Budget Office Working Paper.

Quinn, Joseph F., 1999. "Has the Early Retirement Trend Reversed?" Working Paper, Boston College.

Samwick, Andrew A., 1998.a. "New Evidence on Pensions, Social Security, and the Timing of Retirement," *Journal of Public Economics*, Vol.70, pp.207-236.

Samwick, Andrew A., 1998.b. "Discount Rate Heterogeneity and Social Security Reform," *Journal of Development Economics*, Vol.57, pp.117-146.

Samwick, Andrew A. and Jonathan Skinner, 1998. "How will Defined Contribution Pension Plan Affect Retirement Income," NBER Working Paper No. 6645.

Samwick, Andrew A., 2001. "Comments on Social Security and Incentives for Retirement," in *Themes in Economics of Aging*, edited by David A. Wise. University of Chicago Press, pp.341-354.

Sevak, Purvi, 2001. "Wealth Shocks and Retirement Timing: Evidence from the Nineties," Working Paper, University of Michigan.

Sheshinski, Eytan, 2003. "Annuities and Retirement," in *Assets, Beliefs, and Equilibria in Economics*, edited by Charalambos D. Aliprantis, Kenneth J. Arrow, Peter Hammond, Felix Kubler, Ho-Mon Wu, and Nicholas C. Yannelis. Springer, pp.27-53.

Stata, 1999. *Stata Reference P-St*, Release 6, Stata Press.

Stock, James H. and David A. Wise, 1990. "Pensions, the Option Value of Work, and Retirement," *Econometrica*, Vol. 58, pp. 1151-1180.

Varian, Hal R., 1992. *Microeconomic Analysis*, 3rd ed., W.W. Norton & Company.

Wooldrige, 2002. *Econometric Analysis of Cross Section and Panel Data*, MIT Press.

Yaari, Menahem E., 1965. "Uncertain Lifetime, Life Insurance, and Theory of the Consumer," *Review of Economic Studies*, Vol. 32, pp. 137-150.

Appendix 1

(Question. L14)

You are given the opportunity to take a new and equally good job, with a 50-50 chance it will double your (family) income and a 50-50 chance that it will cut your (family) income by a third. Would you take the new job?

If yes, respondents are asked to answer the following question:

(Question. L14a.)

Suppose the chances were 50-50 that it would double your (family) income, and 50-50 that it would cut it in half. Would you still take the new job?

If no, respondents are asked to answer the following question:

(Question L14b.)

Suppose the chances were 50-50 that it would double your (family) income and 50-50 that it would cut it by 20 percent. Would you then take the new job?

Appendix 2

Dependent variables

expected retirement year (= retirement age, retirement year)

self reported retirement (full + partial retirement): Probit regression

0 = not retirement, 1 = partial retirement and full retirement

self reported retirement: Multinomial regression

0 = not retirement, 1 = partial retirement, 2 = full retirement

Time to retirement in month

actual retirement month, year – January, 1992

Independent Variables

DB only (current job+past job)

DC only (current job+past job)

DB and DC (current job+past job)

log of pension option value at 1992

log of pension value at 1992

log of total wealth

log of household income in 1991

indicator variable for self employed

tenure of current job + past longest job

log of earning

indicator variable for marriage

indicator variable for female

indicator variable for white

year of education

indicator variable for person who was born in US

low probability of live up to 75=0,1,2

high probability of live up to 75=8,9,10

gamma of CRRA utility function

indicator variable for myopic viewpoint: time period in financial planning < 1year

indicator variable for "bequest is important"

indicator variable for "probability of bequest is high"

indicator variable for poor health

dummy for federal health insurance

indicator variable for employer health insurance

indicator variable for by employer-sponsored retiree health insurance

indicator variable for commercial health insurance

annuity equivalent wealth

Table 1
Descriptive statistics

Variable	Total Mean	Total Std. Dev.	No Pension Mean	No Pension Std. Dev.	DB only Mean	DB only Std. Dev.	DC only Mean	DC only Std. Dev.	Both Mean	Both Std. Dev.
Retirement status	0.210	0.407	0.208	0.406	0.245	0.430	0.107	0.309	0.218	0.413
Exp. Retirement age	63.372	3.666	63.816	3.599	62.467	3.672	63.842	3.185	62.889	3.821
Exp. Retirement year	28.027	97.166	25.327	104.184	24.474	85.973	58.937	76.605	32.221	83.035
Age	55.870	3.181	55.865	3.176	55.983	3.220	55.841	3.045	55.742	3.209
Female	0.508	0.500	0.542	0.498	0.453	0.498	0.485	0.500	0.449	0.498
Marriage	0.724	0.447	0.702	0.457	0.748	0.434	0.774	0.419	0.759	0.428
Education	12.269	3.110	11.689	3.226	13.288	2.677	12.604	2.785	13.167	2.684
White	0.726	0.446	0.705	0.456	0.725	0.446	0.783	0.413	0.787	0.409
Born US	0.906	0.292	0.884	0.320	0.933	0.250	0.922	0.268	0.954	0.209
Myopic	0.270	0.444	0.298	0.457	0.227	0.419	0.237	0.426	0.226	0.418
Pension coverage	63.7%									
pension type (self-report)	8328		3026	36.34%	2628	49.57%	1305	24.61%	1369	25.82%
pension type (company data)	8328		4984	59.85%	1653	49.53%	553	16.54%	1138	34.03%
Pension option value ($1,000)	12.924	36.905	0.000	0.000	30.300	50.695	17.839	29.803	41.895	61.534
Pension value ($1,000)	122.501	181.965			130.049	170.374	47.696	69.410	147.889	222.238
Total net wealth ($1,000)	234.600	517.411	247.406	570.864	200.520	343.826	219.825	520.872	235.289	476.502
Household income ($1,000)	51.213	48.917	47.329	53.944	55.627	34.638	56.236	44.247	59.320	43.705
Earnings ($1,000)	22.928	34.084	19.445	37.728	26.748	21.581	28.764	27.304	29.759	33.101
House owner	0.804	0.397	0.762	0.426	0.868	0.339	0.852	0.355	0.871	0.335
Stock/net wealth	0.045	0.133	0.036	0.129	0.051	0.141	0.057	0.132	0.064	0.137
Bonds/net wealth	0.004	0.026	0.004	0.024	0.005	0.032	0.004	0.021	0.005	0.029
AEW	1.459	0.119	1.450	0.120	1.474	0.118	1.469	0.108	1.469	0.120
AEW2	1.300	0.088	1.314	0.084	1.261	0.089	1.324	0.079	1.284	0.084
Relative risk aversion	3.838	1.680	3.751	1.727	3.967	1.593	3.993	1.579	3.951	1.619
DB wealth/ wealth	0.114	0.232			0.397	0.307			0.257	0.240
Low prob. of living after age75	0.115	0.319	0.129	0.335	0.089	0.285	0.099	0.300	0.100	0.300
Poor health	0.199	0.399	0.234	0.424	0.149	0.356	0.154	0.361	0.136	0.343
Federal health insurance	0.134	0.341	0.140	0.347	0.154	0.361	0.083	0.276	0.105	0.306
Employer-provided health insurance	0.521	0.500	0.418	0.493	0.675	0.469	0.660	0.474	0.682	0.466
Employer-provided retiree health insurance	0.380	0.485	0.259	0.438	0.581	0.494	0.434	0.496	0.588	0.492
Commercial health insurance	0.143	0.350	0.154	0.361	0.135	0.342	0.121	0.327	0.120	0.326
Have children younger than age 17	0.133	0.340	0.137	0.343	0.124	0.330	0.141	0.348	0.126	0.332
Number of children	3.212	2.106	3.336	2.189	2.979	1.964	3.189	1.930	3.022	1.971
High bequest importance	0.231	0.421	0.237	0.425	0.234	0.423	0.188	0.391	0.221	0.415
High bequest prob	0.129	0.335	0.121	0.326	0.140	0.347	0.116	0.320	0.152	0.359
	0.134	0.340	0.195	0.396	0.044	0.206	0.038	0.191	0.043	0.203
Self-employed										
Tenure	13.559	10.947	11.839	10.701	16.914	10.829	13.616	10.290	15.518	10.989
Tenure (current and past job)	14.735	10.960	12.480	10.624	18.762	10.340	14.504	10.310	17.750	11.047
Industry: Agriculture, mining & construction	0.072	0.259	0.095	0.293	0.036	0.187	0.056	0.230	0.034	0.182
Industry: Manufacturing & transportation	0.194	0.396	0.167	0.373	0.226	0.418	0.230	0.421	0.253	0.435
Industry: Whole sale & services	0.249	0.432	0.297	0.457	0.129	0.336	0.293	0.456	0.187	0.390
Industry: Professional & pub. Administration	0.239	0.426	0.164	0.370	0.388	0.487	0.291	0.455	0.326	0.469
Occupation: skilled	0.232	0.422	0.182	0.386	0.310	0.463	0.325	0.469	0.296	0.457
Occupation: semi skilled	0.191	0.393	0.185	0.388	0.185	0.388	0.230	0.421	0.207	0.406
Occupation: unskilled	0.335	0.472	0.359	0.480	0.289	0.453	0.320	0.467	0.301	0.459

Table 2

Self-reported retirement status

	1992	1994	1996	1998	2000	2002
Not retirement	6578	5220	4036	3119	2348	1675
(%)	79.0	68.8	58.5	50.9	40.3	30.3
Partial retirement	580	801	891	913	943	996
(%)	7.0	10.6	12.9	14.9	16.2	18.0
Full retirement	1170	1565	1975	2096	2536	2861
(%)	14.0	20.6	28.6	34.2	43.5	51.7
	8328	7586	6902	6128	5827	5532

Table 3
Regression of expected time to retirement

	1		2	
Independent Variables	Coefficient	Std err.	Coefficient	Std err.
Pension, wealth, and earning				
DB only (d)	-0.1682	0.1591	-0.1668	0.1584
DC only (d)	0.4230 **	0.1716	0.4602 *	0.1719
DB & DC (d)	-0.2038	0.1830	-0.1472	0.1829
Pension option value (log)	-0.0037	0.0152	-0.0025	0.0151
Pension wealth (log)	-0.0071	0.0175	-0.0303 **	0.0150
Non-pension wealth (log)	-0.1578 *	0.0225	-0.1548 *	0.0223
Earnings (log)	0.0262	0.0293	0.0361	0.0292
Longevity risk				
AEW			5.2922 *	0.8857
Age	-0.7341 *	0.0176	-0.8247 *	0.0239
Female	-0.7511 *	0.1241		
Risk aversion	0.0059	0.0321		
Pre-annuitized wealth (%)	-1.7039 *	0.3162		
Low prob of. Living at 75 (d)	-0.5741 *	0.1841	-0.5129 *	0.1841
Poor health (d)	-0.3895 **	0.1677	-0.3949 **	0.1681
Health insurance				
Federal Gov. health ins (d)	-0.1026	0.1942	-0.1579	0.1943
Employer hl. Ins (d)	0.6752 *	0.1443	0.7038 *	0.1445
Retiree employer hl. Ins. (d)	-0.6865 *	0.1381	-0.7204 *	0.1382
Commercial hl. Ins. (d)	0.0380	0.1519	0.0296	0.1522
Bequest motive				
Children 17 or younger (d)	0.6309 *	0.1600	0.7068 *	0.1588
Number of Children	0.0161	0.0277	0.0116	0.0276
High bequest import. (d)	0.0711	0.1323	0.0786	0.1327
High bequest prob. (d)	-0.3270 **	0.1634	-0.3064 ***	0.1638
Demographic				
Education (year of)	0.0657 *	0.0237	0.0739 *	0.0237
Married (d)	-0.4248 *	0.1322	-0.3600 *	0.1314
White (d)	0.2065	0.1360	0.2363 ***	0.1362
Born in U.S. (d)	-0.3631 ***	0.1906	-0.3889 **	0.1911
Myopic (d)	-0.3372 *	0.1247	-0.3455 *	0.1249
Job				
Self-employed (d)	1.4620 *	0.1874	1.5243 *	0.1864
Tenure (current job)	-0.0588 *	0.0054	-0.0620 *	0.0053
Industry: manufactory, transport (d)	0.1374	0.2032	0.0954	0.2032
Industry: service (d)	0.3555 ***	0.2054	0.2909	0.2040
Industry: prof. svc & pub admin. (d)	0.2717	0.2183	0.1002	0.2141
Occupation: skilled (d)	0.3847 **	0.1533	0.3606 **	0.1535
Occupation: semi_skilled (d)	0.3171 **	0.1473	0.2125	0.1445
Constant	50.5532 *	1.0882	48.1211 *	1.1005
Number of obs		4451		4451
F		86.78		90.99
Prob > F		0.000		0.000
R-squared		0.393		0.390
Adj R-squared		0.389		0.385

(d) dummy variable
* significant at 1% level
* * significant at 5 level
*** significant at 10% level

Table 4

Regression of expected time to retirement (by pension types)

Independent Variables	1 DB & DC Coefficient	Std err.	2 DB only Coefficient	Std err.	3 DC only Coefficient	Std err.
Pension, wealth, and earning						
DC only (Self report) (d)	0.6508 *	0.1549				
Pension option value (log)	-0.0093	0.0190	-0.0022	0.0224	-0.0360	0.0378
Pension wealth (log)	-0.0128	0.0189	-0.0343	0.0227	0.0300	0.0371
Non-pension wealth (log)	-0.1559 *	0.0330	-0.1027 **	0.0416	-0.2464 *	0.0549
Earnings (log)	0.0207	0.0453	-0.0029	0.0553	0.0749	0.0799
Longevity risk						
AEW	5.2940 *	1.2105	2.7003 ***	1.4949	9.9941 *	2.1314
Age	-0.8462 *	0.0326	-0.7637 *	0.0403	-0.9915 *	0.0566
Low prob of. Living at 75 (d)	-0.4181	0.2650	-0.6091 ***	0.3339	0.0389	0.4437
Poor health (d)	-0.2470	0.2387	-0.3206	0.2909	-0.1757	0.4197
Health insurance						
Federal Gov. health ins (d)	-0.4868 ***	0.2718	-0.4244	0.3108	-0.8178	0.5668
Employer hl. Ins (d)	0.7519 *	0.1976	0.9507 *	0.2610	0.4481	0.3096
Retiree employer hl. Ins. (d)	-0.7264 *	0.1832	-0.8561 *	0.2407	-0.6111 **	0.2877
Commercial hl. Ins. (d)	0.1303	0.2194	0.2651	0.2677	0.0056	0.3886
Bequest motive						
Children 17 or younger (d)	0.5677 *	0.2194	0.7917 *	0.2759	0.1462	0.3632
Number of Children	-0.0327	0.0388	-0.0056	0.0489	-0.0754	0.0637
High bequest import. (d)	0.1507	0.1863	0.1303	0.2312	0.0925	0.3157
High bequest prob. (d)	-0.5773 **	0.2313	-0.7163 **	0.2921	-0.2826	0.3806
Demographic						
Education (year of)	0.0309	0.0350	-0.0318	0.0440	0.1636 *	0.0581
Married (d)	-0.3216 ***	0.1860	-0.3875	0.2359	-0.2271	0.3039
White (d)	0.1710	0.1853	0.3724	0.2284	-0.3440	0.3219
Born in U.S. (d)	-0.0959	0.2801	-0.4057	0.3533	0.6047	0.4655
Myopic (d)	-0.4009 **	0.1708	-0.4222 **	0.2132	-0.3129	0.2887
Job						
Self-employed (d)	1.9835 *	0.2984	2.2862 *	0.3819	1.2747 *	0.4894
Tenure (current job)	-0.0667 *	0.0074	-0.0648 *	0.0092	-0.0651 *	0.0129
Industry: manufactory, transport (d)	0.3673	0.2957	0.5106	0.3965	0.0992	0.4483
Industry: service (d)	0.8935 *	0.3062	1.0282 **	0.4101	0.5331	0.4623
Industry: prof. svc & pub admin. (d)	0.6426 **	0.3048	0.7518 ***	0.4025	0.4487	0.4751
Occupation: skilled (d)	0.3183	0.2181	0.1029	0.2739	0.7535 **	0.3636
Occupation: semi_skilled (d)	-0.0188	0.2015	-0.3370	0.2554	0.5172	0.3288
Constant	49.3506 *	1.5725	48.6625 *	1.9615	50.6466 *	2.6488
Number of obs		2307		1491		816
F		54.10		33.39		22.75
Prob > F		0.000		0		0.000
R-squared		0.408		0.390		0.447
Adj R-squared		0.400		0.378		0.428

(d) dummy variable
* significant at 1% level
* * significant at 5% level
*** significant at 10% level

Table 5
Probit regression of self-reported retirement status

	1			2		
Independent Variables	Coefficient	Std err.	Marginal Effect	Coefficient	Std err.	Marginal Effect
Pension, wealth, and earning						
DB only (d)	0.0052	0.0570	0.0010	0.0062	0.0565	0.0012
DC only (d)	-0.2222 *	0.0668	-0.0401	-0.2102 *	0.0665	-0.0382
DB & DC (d)	-0.5214 *	0.0809	-0.0842	-0.5060 *	0.0801	-0.0824
Pension option value (log)	-0.1810 *	0.0081	-0.0358	-0.1782 *	0.0080	-0.0353
Pension wealth (log)	0.0809 *	0.0068	0.0160	0.0655 *	0.0052	0.0130
Non-pension wealth (log)	0.0076	0.0078	0.0015	0.0117	0.0077	0.0023
Earnings (log)	-0.1550 *	0.0186	-0.0306	-0.1560 *	0.0186	-0.0309
Longevity risk						
AEW				-0.7457 **	0.3299	-0.1476
Age	0.0569 *	0.0069	0.0112	0.0686 *	0.0091	0.0136
Female	0.0798 ***	0.0485	0.0158			
Risk aversion	-0.0516 *	0.0121	-0.0102			
Pre-annuitized wealth (%)	-0.3170 **	0.1410	-0.0626			
Low prob of. Living at 75 (d)	0.2380 *	0.0633	0.0523	0.2395 *	0.0630	0.0528
Poor health (d)	0.7029 *	0.0525	0.1765	0.7118 *	0.0524	0.1795
Health insurance						
Federal Gov. health ins (d)	0.7372 *	0.0558	0.1941	0.7196 *	0.0555	0.1887
Employer hl. Ins (d)	-0.6319 *	0.0666	-0.1312	-0.6378 *	0.0664	-0.1327
Retiree employer hl. Ins. (d)	0.4355 *	0.0694	0.0902	0.4255 *	0.0692	0.0882
Commercial hl. Ins. (d)	-0.1141 **	0.0564	-0.0215	-0.1159 **	0.0563	-0.0218
Bequest motive						
Children 17 or younger (d)	-0.1607 **	0.0711	-0.0296	-0.1583 **	0.0705	-0.0292
Number of Children	0.0227 **	0.0103	0.0045	0.0230 **	0.0103	0.0046
High bequest import. (d)	-0.0929 ***	0.0519	-0.0178	-0.0933 ***	0.0518	-0.0179
High bequest prob. (d)	0.2100 *	0.0632	0.0453	0.2182 *	0.0631	0.0473
Demographic						
Education (year of)	0.0350 *	0.0090	0.0069	0.0357 *	0.0089	0.0071
Married (d)	0.0840	0.0530	0.0162	0.0862	0.0527	0.0167
White (d)	0.0781	0.0529	0.0151	0.0872 ***	0.0527	0.0168
Born in U.S. (d)	0.2143 **	0.0832	0.0380	0.2084 **	0.0829	0.0371
Myopic (d)	0.1201 *	0.0457	0.0245	0.1218 *	0.0456	0.0250
Job						
Self-employed (d)	-0.1532 *	0.0589	-0.0284	-0.1481 **	0.0585	-0.0276
Tenure	0.0262 *	0.0021	0.0052	0.0250 *	0.0021	0.0049
Industry: manufactory, transport (d)	0.0847	0.0777	0.0171	0.0874	0.0773	0.0177
Industry: service (d)	0.0989	0.0755	0.0199	0.1061	0.0744	0.0215
Industry: prof. svc & pub admin. (d)	-0.0440	0.0849	-0.0086	-0.0493	0.0825	-0.0096
Occupation: skilled (d)	0.0244	0.0596	0.0049	0.0248	0.0595	0.0049
Occupation: semi_skilled (d)	0.1209 **	0.0556	0.0247	0.1191 **	0.0548	0.0244
Constant	-3.6529 *	0.4501		-3.5030 *	0.4577	
Number of obs		7206			7206	
Log likelihood		-2488.3			-2498.6	
LR chi2		2508.67			2488.1	
Prob > chi2		0.000			0.000	
Pseudo R2		0.335			0.332	

(d) dummy variable
* significant at 1% level
* * significant at 5% level
*** significant at 10% level

Table 6

Multinomial logit regression of self-reported retirement status

	1						2					
	Partial retirement		Full retirement		Marginal effect		Partial retirement		Full retirement		Marginal effect	
Independent Variables	Coefficient	Std err.	Coefficient	Std err.	Partial Ret	Full Ret	Coefficient	Std err.	Coefficient	Pr > |t|	Partial Ret	Full Ret
Pension, wealth, and earning												
DB only (d)	0.083	0.138	-0.044	0.124	0.004	-0.002	0.118	0.136	-0.060	0.626	0.006	-0.002
DC only (d)	-0.215	0.165	-0.578 *	0.152	-0.010	-0.021	-0.202	0.165	-0.551 *	0.000	-0.009	-0.017
DB & DC (d)	-0.654 *	0.198	-1.261 *	0.188	-0.030	-0.045	-0.609 *	0.196	-1.249 *	0.000	-0.024	-0.034
Pension option value (log)	-0.252 *	0.021	-0.471 *	0.032	-0.012	-0.017	-0.252 *	0.020	-0.461 *	0.000	-0.012	-0.017
Pension wealth (log)	0.104 *	0.016	0.174 *	0.014	0.005	0.006	0.097 *	0.012	0.129 *	0.000	0.005	0.005
Non-pension wealth (log)	0.047 **	0.021	-0.004	0.016	0.002	0.000	0.045 **	0.021	0.010	0.528	0.002	0.000
Earnings (log)	-0.162 *	0.046	-0.350 *	0.038	-0.007	-0.013	-0.164 *	0.046	-0.349 *	0.000	-0.007	-0.013
Longevity risk												
AEW							-0.846	0.791	-1.792 *	0.010	-0.039	-0.066
Age	0.064 *	0.017	0.138 *	0.015	0.003	0.005	0.076 *	0.022	0.166 *	0.000	0.003	0.006
Female	-0.037	0.116	0.325 *	0.106	-0.002	0.012						
Risk aversion	-0.087 *	0.029	-0.090 *	0.026	-0.004	-0.003						
Pre-annuitized wealth (%)	-0.069	0.333	-0.967 *	0.297	-0.001	-0.036						
Low prob of. Living at 75 (d)	0.532 *	0.150	0.342 *	0.130	0.026	0.012	0.548 *	0.149	0.327 **	0.011	0.032	0.012
Poor health (d)	0.617 *	0.135	1.619 *	0.108	0.027	0.059	0.627 *	0.135	1.637 *	0.000	0.029	0.101
Health insurance												
Federal Gov. health ins (d)	1.041 *	0.133	1.396 *	0.111	0.049	0.050	1.026 *	0.132	1.361 *	0.000	0.064	0.077
Employer hl. Ins (d)	-0.987 *	0.169	-1.260 *	0.157	-0.047	-0.045	-0.961 *	0.168	-1.306 *	0.000	-0.048	-0.053
Retiree employer hl. Ins. (d)	0.625 *	0.176	0.966 *	0.162	0.029	0.035	0.596 *	0.175	0.969 *	0.000	0.029	0.039
Commercial hl. Ins. (d)	0.085	0.124	-0.471 *	0.129	0.005	-0.018	0.085	0.123	-0.457 *	0.000	0.005	-0.015
Bequest motive												
Children 17 or younger (d)	-0.314 ***	0.173	-0.218	0.162	-0.015	-0.007	-0.289 ***	0.172	-0.233	0.145	-0.013	-0.008
Number of Children	0.056 **	0.025	0.028	0.022	0.003	0.001	0.054 **	0.025	0.032	0.147	0.003	0.001
High bequest import. (d)	-0.311 **	0.131	-0.006	0.110	-0.016	0.000	-0.308 **	0.131	-0.022	0.843	-0.014	0.000
High bequest prob. (d)	0.490 *	0.146	0.263 ***	0.141	0.024	0.009	0.495 *	0.146	0.294 **	0.036	0.028	0.011
Demographic												
Education (year of)	0.058 *	0.022	0.062 *	0.019	0.003	0.002	0.063 *	0.022	0.059 *	0.002	0.003	0.002
Married (d)	0.073	0.129	0.241 **	0.114	0.003	0.009	0.095	0.129	0.224 **	0.049	0.004	0.008
White (d)	0.032	0.130	0.179	0.113	0.001	0.007	0.035	0.130	0.211 ***	0.061	0.001	0.007
Born in U.S. (d)	0.270	0.205	0.476 **	0.188	0.013	0.017	0.252	0.205	0.471 **	0.012	0.011	0.015
Myopic (d)	-0.045	0.115	0.408 *	0.095	-0.003	0.015	-0.051	0.115	0.414 *	0.000	-0.003	0.017
Job												
Self-employed (d)	0.314 **	0.129	-1.045 *	0.150	0.018	-0.039	0.345 *	0.128	-1.042 *	0.000	0.021	-0.030
Tenure	0.042 *	0.005	0.050 *	0.005	0.002	0.002	0.041 *	0.005	0.046 *	0.000	0.002	0.002
Industry: manufactory, transport (d)	-0.308 ***	0.186	0.420 **	0.172	-0.016	0.016	-0.320 ***	0.186	0.451 *	0.008	-0.016	0.020
Industry: service (d)	0.291 ***	0.168	0.077	0.173	0.014	0.002	0.263	0.166	0.144	0.398	0.013	0.005
Industry: prof. svc & pub admin. (d)	0.001	0.195	-0.191	0.190	0.000	-0.007	-0.053	0.191	-0.132	0.474	-0.002	-0.005
Occupation: skilled (d)	-0.236 ***	0.143	0.254 ***	0.131	-0.012	0.010	-0.236 ***	0.143	0.254 **	0.050	-0.012	0.011
Occupation: semi_skilled (d)	-0.048	0.135	0.417 *	0.120	-0.003	0.016	-0.072	0.134	0.438 *	0.000	-0.005	0.018
Constant	-6.253 *	1.095	-8.581 *	0.987			-6.166 *	1.108	-8.042 *	0.000		
Number of obs			7192						7192			
Log likelihood			-3264.26						-3280.79			
LR chi2			2939.09						2906.02			
Prob > chi2			0.000						0.000			
Pseudo R2			0.310						0.307			

(d) dummy variable

* significant at 1% level

* * significant at 5% level

*** significant at 10% level

Table 7
Probit regression of change in self-reported retirement status from Wave1 to Wave 2

	1			2		
Independent Variables	Coefficient	Std err.	Marginal Effect	Coefficient	Std err.	Marginal Effect
Pension, wealth, and earning						
DB only (d)	0.1095	0.0727	0.0197	0.1221 ***	0.0720	0.0220
DC only (d)	0.0936	0.0782	0.0170	0.0872	0.0781	0.0158
DB & DC (d)	-0.0067	0.0857	-0.0012	-0.0016	0.0852	-0.0003
Pension option value (log)	-0.0257 *	0.0073	-0.0045	-0.0274 *	0.0073	-0.0048
Pension wealth (log)	0.0232 *	0.0084	0.0041	0.0305 *	0.0071	0.0053
Non-pension wealth (log)	0.0283 *	0.0108	0.0049	0.0245 **	0.0105	0.0043
Earnings (log)	-0.0451 *	0.0112	-0.0079	-0.0443 *	0.0112	-0.0077
Longevity risk						
AEW				-0.5021	0.3925	-0.0879
Age	0.1187 *	0.0082	0.0207	0.1264 *	0.0110	0.0221
Female	0.0078	0.0572	0.0014			
Risk aversion	-0.0260 ***	0.0147	-0.0045			
Pre-annuitized wealth (%)	0.3036 **	0.1455	0.0530			
Low prob of. Living at 75 (d)	-0.0067	0.0876	-0.0012	-0.0034	0.0874	-0.0006
Poor health (d)	0.2644 *	0.0715	0.0523	0.2634 *	0.0715	0.0522
Health insurance						
Federal Gov. health ins (d)	0.2692 *	0.0812	0.0542	0.2769 *	0.0809	0.0561
Employer hl. Ins (d)	-0.2358 *	0.0691	-0.0425	-0.2293 *	0.0689	-0.0414
Retiree employer hl. Ins. (d)	0.2227 *	0.0683	0.0398	0.2247 *	0.0681	0.0403
Commercial hl. Ins. (d)	-0.0115	0.0661	-0.0020	-0.0059	0.0659	-0.0010
Bequest motive						
Children 17 or younger (d)	-0.1838 **	0.0835	-0.0295	-0.1770 **	0.0828	-0.0286
Number of Children	0.0075	0.0126	0.0013	0.0070	0.0126	0.0012
High bequest import. (d)	-0.0078	0.0628	-0.0014	-0.0077	0.0628	-0.0013
High bequest prob. (d)	0.0591	0.0760	0.0106	0.0571	0.0760	0.0103
Demographic						
Education (year of)	0.0072	0.0110	0.0013	0.0088	0.0110	0.0015
Married (d)	-0.0944	0.0603	-0.0170	-0.0902	0.0597	-0.0162
White (d)	0.0438	0.0644	0.0075	0.0366	0.0642	0.0063
Born in U.S. (d)	0.4912 *	0.1135	0.0656	0.4917 *	0.1134	0.0659
Myopic (d)	0.0764	0.0563	0.0137	0.0756	0.0562	0.0136
Job						
Self-employed (d)	-0.1418 ***	0.0820	-0.0232	-0.1286	0.0812	-0.0213
Tenure	0.0071 *	0.0024	0.0012	0.0075 *	0.0024	0.0013
Industry: manufactory, transport (d)	0.0309	0.0975	0.0055	0.0245	0.0971	0.0043
Industry: service (d)	0.1591 ***	0.0956	0.0289	0.1430	0.0945	0.0259
Industry: prof. svc & pub admin. (d)	0.0263	0.1032	0.0046	0.0112	0.1007	0.0020
Occupation: skilled (d)	0.0267	0.0702	0.0047	0.0266	0.0702	0.0047
Occupation: semi_skilled (d)	-0.0009	0.0670	-0.0002	-0.0099	0.0658	-0.0017
Constant	-8.4208 *	0.5200	-1.4704	-8.2721 *	0.5214	
Number of obs		5236			5236	
Log likelihood		-1762.43			-1765.26	
LR chi2		480.59			474.93	
Prob > chi2		0.000			0.000	
Pseudo R2		0.120			0.1186	

(d) dummy variable
* significant at 1% level
* * significant at 5% level
*** significant at 10% level

Table 8

Multinomial logit regression of change in self-reported retirement status from Wave1 to Wave 2

	1						2					
	Partial retirement		Full retirement		Marginal effect		Partial retirement		Full retirement		Marginal effect	
Independent Variables	Coefficient	Std err.	Coefficient	Std err.	Partial Ret	Full Ret	Coefficient	Std err.	Coefficient	Std err.	Partial Ret	Full Ret
Pension, wealth, and earning												
DB only (d)	-0.039	0.183	0.408 **	0.190	-0.003	0.017	0.024	0.180	0.405 **	0.189	0.000	0.018
DC only (d)	0.067	0.194	0.302	0.206	0.002	0.012	0.061	0.194	0.295	0.206	0.002	0.013
DB & DC (d)	-0.194	0.220	0.171	0.219	-0.009	0.007	-0.145	0.218	0.163	0.218	-0.007	0.007
Pension option value (log)	-0.057 *	0.019	-0.029 ***	0.017	-0.003	-0.001	-0.062 *	0.019	-0.030 ***	0.017	-0.003	-0.001
Pension wealth (log)	0.044 **	0.021	0.031	0.020	0.002	0.001	0.067 *	0.017	0.033 **	0.017	0.003	0.001
Non-pension wealth (log)	0.039	0.028	0.066 **	0.031	0.002	0.003	0.025	0.027	0.066 **	0.030	0.001	0.003
Earnings (log)	-0.069 *	0.024	-0.105 *	0.033	-0.003	-0.004	-0.065 *	0.024	-0.106 *	0.033	-0.003	-0.004
Longevity risk												
AEW							-0.556	0.992	-0.520	0.936	-0.025	-0.020
Age	0.191 *	0.021	0.261 *	0.022	0.008	0.010	0.199 *	0.028	0.269 *	0.028	0.009	0.011
Female	-0.172	0.146	0.089	0.142	-0.008	0.004						
Risk aversion	-0.067 ***	0.037	-0.024	0.038	-0.003	-0.001						
Pre-annuitized wealth (%)	0.805 **	0.385	0.176	0.342	0.037	0.006						
Low prob of. Living at 75 (d)	-0.126	0.240	0.058	0.209	-0.006	0.003	-0.107	0.239	0.054	0.209	-0.005	0.002
Poor health (d)	0.134	0.197	0.824 *	0.161	0.004	0.033	0.125	0.197	0.824 *	0.161	0.004	0.045
Health insurance												
Federal Gov. health ins (d)	0.504 *	0.193	0.396 **	0.193	0.022	0.015	0.539 *	0.192	0.400 **	0.192	0.030	0.017
Employer hl. Ins (d)	-0.441 **	0.182	-0.530 *	0.178	-0.019	-0.021	-0.405 **	0.180	-0.534 *	0.177	-0.018	-0.022
Retiree employer hl. Ins. (d)	0.360 **	0.183	0.533 *	0.170	0.016	0.021	0.351 ***	0.181	0.535 *	0.170	0.016	0.022
Commercial hl. Ins. (d)	0.035	0.161	-0.046	0.165	0.002	-0.002	0.052	0.161	-0.042	0.165	0.003	-0.002
Bequest motive												
Children 17 or younger (d)	-0.344	0.226	-0.473 **	0.237	-0.015	-0.019	-0.291	0.224	-0.482 **	0.236	-0.012	-0.016
Number of Children	0.026	0.033	0.011	0.031	0.001	0.000	0.023	0.033	0.012	0.031	0.001	0.000
High bequest import. (d)	-0.176	0.169	0.209	0.150	-0.009	0.009	-0.172	0.169	0.209	0.150	-0.008	0.009
High bequest prob. (d)	0.134	0.197	0.047	0.186	0.006	0.002	0.120	0.197	0.047	0.186	0.006	0.002
Demographic												
Education (year of)	0.026	0.028	-0.014	0.027	0.001	-0.001	0.033	0.028	-0.014	0.027	0.002	-0.001
Married (d)	-0.198	0.155	-0.146	0.150	-0.009	-0.006	-0.167	0.154	-0.156	0.148	-0.008	-0.006
White (d)	0.164	0.176	-0.032	0.156	0.008	-0.002	0.148	0.176	-0.037	0.155	0.007	-0.002
Born in U.S. (d)	0.685 **	0.295	1.285 *	0.358	0.029	0.051	0.674 **	0.294	1.288 *	0.358	0.024	0.033
Myopic (d)	-0.059	0.150	0.385 *	0.133	-0.004	0.016	-0.074	0.150	0.387 *	0.133	-0.004	0.018
Job												
Self-employed (d)	0.177	0.186	-1.191 *	0.282	0.011	-0.049	0.230	0.184	-1.200 *	0.280	0.014	-0.035
Tenure	-0.009	0.006	0.031 *	0.006	0.000	0.001	-0.007	0.006	0.031 *	0.006	0.000	0.001
Industry: manufactory, transport (d)	-0.299	0.236	0.446	0.281	-0.015	0.019	-0.329	0.236	0.454	0.281	-0.015	0.021
Industry: service (d)	0.165	0.219	0.421	0.287	0.007	0.017	0.093	0.216	0.432	0.284	0.003	0.019
Industry: prof. svc & pub admin. (d)	-0.317	0.251	0.400	0.295	-0.015	0.017	-0.408 ***	0.245	0.421	0.289	-0.019	0.019
Occupation: skilled (d)	-0.227	0.182	0.378 **	0.174	-0.011	0.016	-0.237	0.183	0.382 **	0.173	-0.011	0.017
Occupation: semi_skilled (d)	-0.021	0.165	0.017	0.171	-0.001	0.001	-0.078	0.162	0.028	0.168	-0.004	0.001
Constant	-13.532 *	1.343	-19.262 *	1.415	-0.585	-0.755	-13.565 *	1.349	-19.0639 *	1.4119		
Number of obs			4963						4963			
Log likelihood			-2112.52						-2117.5			
LR chi2			627.60						617.64			
Prob > chi2			0.000						0.000			
Pseudo R2			0.129						0.127			

(d) dummy variable

* significant at 1% level

* * significant at 5% level

*** significant at 10% level

Table 9

Survival regression of time to retirement year

Independent Variables	1 Gamma Coefficient	Std err.	2 Loglogistic Coefficient	Std err.	3 Weibull - AFT Coefficient	Std err.	4 Cox - Hazard ratio Coefficient	Std err.
Pension, wealth, and earning								
DB only (d)	-0.1045	0.0720	-0.1039	0.0733	-0.1028	0.0680	0.1056	0.0729
DC only (d)	-0.0269	0.0774	-0.0002	0.0779	-0.0512	0.0730	0.0502	0.0784
DB & DC (d)	0.0572	0.0871	0.0955	0.0868	0.0193	0.0822	-0.0232	0.0882
Pension option value (log)	0.0434 *	0.0077	0.0509 *	0.0080	0.0344 *	0.0071	-0.0361 *	0.0076
Pension wealth (log)	-0.0446 *	0.0075	-0.0528 *	0.0078	-0.0363 *	0.0068	0.0384 *	0.0073
Non-pension wealth (log)	-0.0071	0.0098	-0.0069	0.0099	-0.0073	0.0093	0.0086	0.0100
Earnings (log)	0.0249 **	0.0115	0.0261 **	0.0119	0.0230 **	0.0107	-0.0244 **	0.0115
Longevity risk								
AEW	0.7370 ***	0.3982	0.7539 ***	0.4186	0.7481	0.3672	-0.8192 **	0.3939
Age	-0.1740 *	0.0113	-0.1740 *	0.0115	-0.1690 *	0.0106	0.1806 *	0.0113
Female								
Risk aversion								
Pre-annuitized wealth (%)								
Low prob of. Living at 75 (d)	-0.1591 ***	0.0865	-0.1103	0.0897	-0.1688 **	0.0803	0.1786 **	0.0861
Poor health (d)	-0.5122 *	0.0741	-0.6069 *	0.0779	-0.4211 *	0.0661	0.4505 *	0.0706
Health insurance								
Federal Gov. health ins (d)	-0.4084 *	0.0868	-0.4533 *	0.0940	-0.3524 *	0.0788	0.3817 *	0.0845
Employer hl. Ins (d)	0.3782 *	0.0679	0.3651 *	0.0690	0.3658 *	0.0640	-0.3855 *	0.0685
Retiree employer hl. Ins. (d)	-0.3335 *	0.0676	-0.3346 *	0.0685	-0.3180 *	0.0637	0.3389 *	0.0682
Commercial hl. Ins. (d)	0.1218 ***	0.0696	0.1236 ***	0.0713	0.1138 ***	0.0655	-0.1203 ***	0.0703
Bequest motive								
Children 17 or younger (d)	0.2637 *	0.0780	0.2541 *	0.0780	0.2601 *	0.0753	-0.2761 *	0.0807
Number of Children	-0.0038	0.0127	-0.0044	0.0129	-0.0031	0.0119	0.0036	0.0128
High bequest import. (d)	-0.0591	0.0626	-0.0374	0.0646	-0.0657	0.0584	0.0702	0.0627
High bequest prob. (d)	-0.0642	0.0762	-0.0941	0.0795	-0.0414	0.0711	0.0436	0.0763
Demographic								
Education (year of)	0.0032	0.0106	0.0008	0.0109	0.0069	0.0098	-0.0071	0.0105
Married (d)	-0.0620	0.0609	-0.0454	0.0621	-0.0698	0.0573	0.0729	0.0615
White (d)	-0.1234 ***	0.0654	-0.1057	0.0668	-0.1299 **	0.0616	0.1419 **	0.0661
Born in U.S. (d)	-0.1029	0.0954	-0.1549	0.0947	-0.0706	0.0907	0.0747	0.0972
Myopic (d)	-0.0513	0.0569	-0.0311	0.0581	-0.0629	0.0534	0.0697	0.0573
Job								
Self-employed (d)	0.2458 *	0.0783	0.2313 *	0.0804	0.2523 *	0.0746	-0.2677 *	0.0800
Tenure	-0.0163 *	0.0025	-0.0176 *	0.0026	-0.0145 *	0.0023	0.0155 *	0.0024
Industry: manufactory, transport (d)	-0.0019	0.0924	-0.0436	0.0939	0.0214	0.0862	-0.0256	0.0925
Industry: service (d)	0.0750	0.0905	0.0249	0.0919	0.1070	0.0848	-0.1097	0.0910
Industry: prof. svc & pub admin. (d)	0.1800 ***	0.0967	0.1395	0.0977	0.1866 **	0.0908	-0.1985 **	0.0975
Occupation: skilled (d)	0.0885	0.0707	0.0812	0.0726	0.0934	0.0663	-0.1059	0.0712
Occupation: semi_skilled (d)	0.0312	0.0667	0.0084	0.0680	0.0419	0.0628	-0.0465	0.0673
Constant	13.6736	0.5160	13.5044	0.5203	13.4141	0.4890		
ln_sig	0.0719	0.0322	-0.3308	0.0207	0.0706	0.0208		
sigma/gamma/p	1.0746	0.0346	0.7183	0.0149	1.0731	0.0224		
kappa	0.6285	0.0686						
Number of obs		2957		2957		2957		2957
Log likelihood		-3731.45		-3722.82		-3745.02		-12867.18
LR chi2		860.86		870.20		849.30		830.82
Prob > chi2		0.000		0.000		0.000		0.000

(d) dummy variable

* significant at 1% level

* * significant at 5% level

*** significant at 10% level

Table 10
Regression of expected time to retirement and Probit regression of self-reported retirement status (Willingness to annuitize)

	OLS			Probit		
Independent Variables	Coefficient		Std err.	Coefficient		Std err.
Willingness to annuitize	0.3490		0.1690	-1.1105	*	0.1585
Pension, wealth, and earning						
DB only (d)	-0.1492		0.1586	-0.0091		0.0567
DC only (d)	0.3504	***	0.1799	-0.0828		0.0687
DB & DC (d)	-0.2366		0.1879	-0.3707	*	0.0825
Pension option value (log)	-0.0048		0.0151	-0.1757	*	0.0081
Pension wealth (log)	-0.0304	**	0.0150	0.0645	*	0.0053
Non-pension wealth (log)	-0.1544	*	0.0223	0.0120		0.0077
Earnings (log)	0.0358		0.0292	-0.1558	*	0.0187
Longevity risk						
AEW	5.2327	*	0.8858	-0.7451	**	0.3323
Age	-0.8226	*	0.0239	0.0672	*	0.0092
Low prob of. Living at 75 (d)	-0.5130	*	0.1841	0.2403	*	0.0634
Poor health (d)	-0.3865	**	0.1681	0.7013	*	0.0527
Health insurance						
Federal Gov. health ins (d)	-0.1481		0.1943	0.7085	*	0.0557
Employer hl. Ins (d)	0.7121	*	0.1445	-0.6631	*	0.0672
Retiree employer hl. Ins. (d)	-0.7274	*	0.1382	0.4468	**	0.0701
Commercial hl. Ins. (d)	0.0326		0.1522	-0.1366	*	0.0566
Bequest motive						
Children 17 or younger (d)	0.7091	*	0.1588	-0.1434	**	0.0710
Number of Children	0.0128		0.0276	0.0221	***	0.0103
High bequest import. (d)	0.0797		0.1326	-0.0952	*	0.0521
High bequest prob. (d)	-0.2987	***	0.1638	0.2042	*	0.0634
Demographic						
Education (year of)	0.0742	*	0.0237	0.0359	*	0.0090
Married (d)	-0.3599	*	0.1313	0.0878	***	0.0530
White (d)	0.2334	***	0.1362	0.0888	***	0.0530
Born in U.S. (d)	-0.3847	**	0.1910	0.2136	*	0.0834
Myopic (d)	-0.3428	*	0.1249	0.1190	*	0.0459
Job						
Self-employed (d)	1.5345	*	0.1864	-0.1746	*	0.0588
Tenure (current job)	-0.0624	*	0.0053	0.0261	*	0.0021
Industry: manufactory, transport (d)	0.0982		0.2031	0.0825		0.0777
Industry: service (d)	0.2928		0.2039	0.1075		0.0747
Industry: prof. svc & pub admin. (d)	0.0865		0.2141	-0.0417		0.0830
Occupation: skilled (d)	0.3613	**	0.1534	0.0334		0.0599
Occupation: semi_skilled (d)	0.2141		0.1444	0.1283	**	0.0552
Constant	48.0728	*	1.1003	-3.4330	*	0.4600
	Number of obs		4451	Number of obs		7206
	F		87.35	Log likelihood		-2464.1471
	Prob > F		0.000	LR chi2		2556.92
	R-squared		0.390	Prob > chi2		0.000
	Adj R-squared		0.386	Pseudo R2		0.342

(d) dummy variable
* significant at 1% level
* * significant at 5 level
*** significant at 10% level

Table 11

Regression of expected time to retirement and Probit regression of self-reported retirement status (Changes in interest rate for pension value calculation)

	OLS s2		OLS s3		Probit s2		Probit s3	
Independent Variables	Coefficient	Std err.	Coefficient	Std err.	Coefficient	Std err.	Coefficient	Std err.
Pension, wealth, and earning								
DB only (d)	-0.1666	0.1585	-0.1678	0.1584	0.0050	0.0565	0.0060	0.0565
DC only (d)	0.4601 *	0.1719	0.4592 *	0.1719	-0.2076 *	0.0665	-0.2109 *	0.0665
DB & DC (d)	-0.1473	0.1830	-0.1488	0.1829	-0.4986 *	0.0802	-0.5068 *	0.0801
Pension option value (log)	-0.0022	0.0151	-0.0017	0.0151	-0.1791 *	0.0080	-0.1792 *	0.0081
Pension wealth (log)	-0.0306 **	0.0151	-0.0308 **	0.0150	0.0663 *	0.0053	0.0656 *	0.0052
Non-pension wealth (log)	-0.1548 *	0.0223	-0.1548 *	0.0223	0.0116	0.0077	0.0117	0.0077
Earnings (log)	0.0361	0.0292	0.0360	0.0292	-0.1559 *	0.0186	-0.1561 *	0.0186
Longevity risk								
AEW	5.2860 *	0.8856	5.2918 *	0.8855	-0.7582 **	0.3304	-0.7471 **	0.3298
Age	-0.8245 *	0.0239	-0.8245 *	0.0239	0.0681 *	0.0092	0.0687 *	0.0091
Low prob of. Living at 75 (d)	-0.5131 *	0.1841	-0.5131 *	0.1841	0.2387 *	0.0630	0.2412 *	0.0630
Poor health (d)	-0.3949 **	0.1681	-0.3948 **	0.1681	0.7095 *	0.0524	0.7137 *	0.0524
Health insurance								
Federal Gov. health ins (d)	-0.1575	0.1943	-0.1571	0.1943	0.7193 *	0.0555	0.7179 *	0.0555
Employer hl. Ins (d)	0.7037 *	0.1445	0.7036 *	0.1445	-0.6360 *	0.0664	-0.6347 *	0.0664
Retiree employer hl. Ins. (d)	-0.7203 *	0.1382	-0.7207 *	0.1382	0.4250 *	0.0693	0.4213 **	0.0692
Commercial hl. Ins. (d)	0.0297	0.1522	0.0297	0.1522	-0.1114 **	0.0564	-0.1151 *	0.0563
Bequest motive								
Children 17 or younger (d)	0.7068 *	0.1588	0.7068 *	0.1588	-0.1603 **	0.0706	-0.1587 **	0.0705
Number of Children	0.0116	0.0276	0.0116	0.0276	0.0230 **	0.0103	0.0231 ***	0.0103
High bequest import. (d)	0.0785	0.1327	0.0785	0.1327	-0.0961 ***	0.0518	-0.0944 *	0.0518
High bequest prob. (d)	-0.3063 ***	0.1638	-0.3061 ***	0.1638	0.2184 *	0.0631	0.2217 *	0.0631
Demographic								
Education (year of)	0.0739 *	0.0237	0.0739 *	0.0237	0.0353 *	0.0089	0.0361 *	0.0089
Married (d)	-0.3598 *	0.1314	-0.3597 *	0.1314	0.0854	0.0527	0.0855	0.0527
White (d)	0.2363 ***	0.1362	0.2364 ***	0.1362	0.0841	0.0528	0.0878 ***	0.0527
Born in U.S. (d)	-0.3888 **	0.1911	-0.3887 **	0.1911	0.2070 **	0.0830	0.2047 **	0.0829
Myopic (d)	-0.3454 *	0.1249	-0.3453 *	0.1249	0.1193 *	0.0457	0.1215 *	0.0456
Job								
Self-employed (d)	1.5245 *	0.1864	1.5252 *	0.1864	-0.1497 *	0.0585	-0.1492 **	0.0585
Tenure (current job)	-0.0620 *	0.0053	-0.0620 *	0.0053	0.0251 *	0.0021	0.0250 *	0.0021
Industry: manufactory, transport (d)	0.0954	0.2032	0.0953	0.2032	0.0862	0.0773	0.0895	0.0773
Industry: service (d)	0.2909	0.2040	0.2910	0.2040	0.1069	0.0744	0.1062	0.0744
Industry: prof. svc & pub admin. (d)	0.0999	0.2141	0.0992	0.2141	-0.0471	0.0826	-0.0526	0.0825
Occupation: skilled (d)	0.3605 **	0.1535	0.3605 **	0.1535	0.0231	0.0595	0.0236	0.0595
Occupation: semi_skilled (d)	0.2124	0.1445	0.2126	0.1445	0.1192 **	0.0549	0.1194 **	0.0548
Constant	48.1198 *	1.1010	48.1102 *	1.1005	-3.4551 *	0.4580	-3.5089 *	0.4577
	Number of obs	4451		4451	Number of obs	7206		7206
	F	91.00		90.99	Log likelihood	-2493.8		-2498.12
	Prob > F	0.000		0.000	LR chi2	2497.62		2488.96
	R-squared	0.390		0.390	Prob > chi2	0.000		0.000
	Adj R-squared	0.385		0.385	Pseudo R2	0.334		0.333

Pension value is calculated on the following assumption.
s2: Interest rate 6.0% Wage growth 5% Inflation rate 4%
s3: Interest rate 6.5% Wage growth 5% Inflation rate 4%
Base scenario: Interest rate 6.3% Wage growth 5% Inflation rate 4%

(d) dummy variable
* significant at 1% level
* * significant at 5 level
*** significant at 10% level

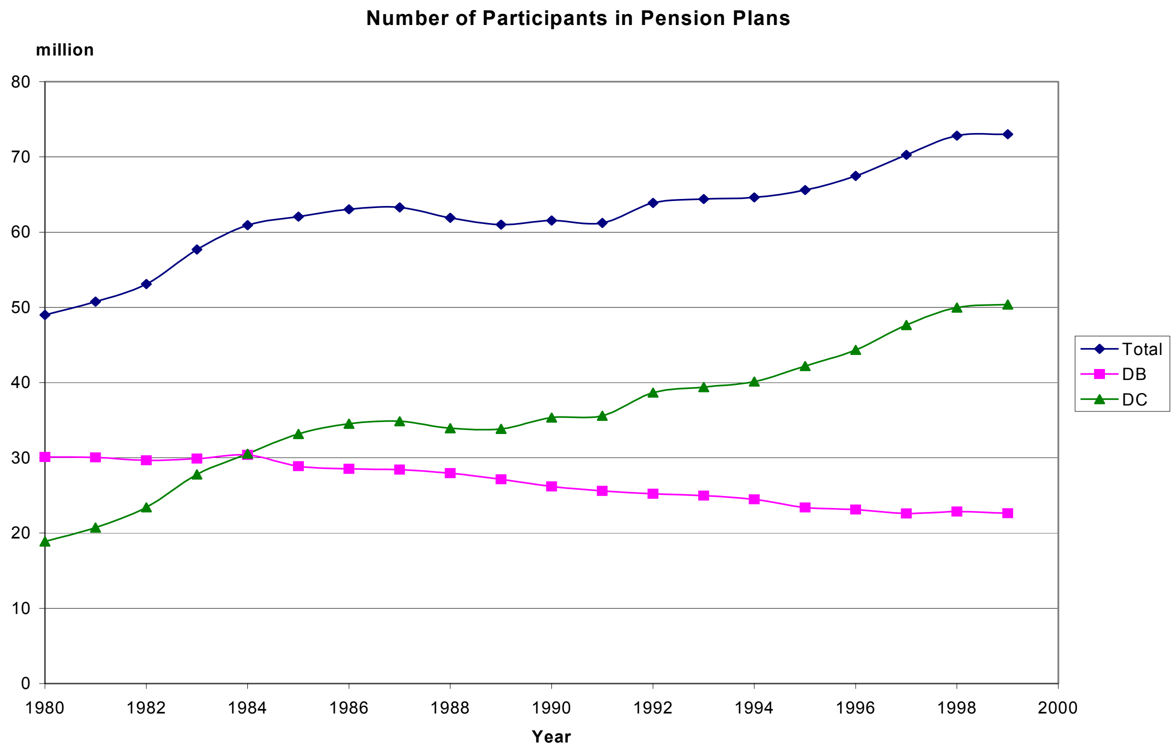
Table 12
Regression of expected time to retirement and Probit regression of self-reported retirement status (Changes in utility discount rates for AEW calculation)

	1		2		3	
	OLS		Probit		Probit	
Independent Variables	Coefficient	Std err.	Coefficient	Std err.	Coefficient	Std err.
Pension, wealth, and earning						
DB only (d)	-0.1390	0.1587	-0.0045	0.0563	0.0703	0.0635
DC only (d)	0.4899 *	0.1722	-0.2197 *	0.0664	-0.1953 *	0.0740
DB & DC (d)	-0.0825	0.1828	-0.5257 *	0.0798	-0.4772 *	0.0865
Pension option value (log)	0.0007	0.0151	-0.1791 *	0.0080	-0.1748 *	0.0087
Pension wealth (log)	-0.0405 *	0.0150	0.0697 *	0.0052	0.0629 *	0.0056
Non-pension wealth (log)	-0.1601 *	0.0230	0.0103	0.0079	0.2268 *	0.0284
Earnings (log)	0.0465	0.0292	-0.1551 *	0.0186	-0.3944 *	0.0371
Longevity risk						
AEW	2.1919 *	0.5576	-0.0064	0.2120	-0.7715 *	0.2868
Age	-0.7673 *	0.0202	0.0550 *	0.0079	0.0627 *	0.0094
Low prob of. Living at 75 (d)	-0.4869 *	0.1846	0.2347 *	0.0629	0.2213 *	0.0744
Poor health (d)	-0.3957 **	0.1685	0.7091 *	0.0524	0.6318 *	0.0628
Health insurance						
Federal Gov. health ins (d)	-0.1722	0.1947	0.7212 *	0.0555	0.5958 *	0.0647
Employer hl. Ins (d)	0.7298 *	0.1447	-0.6387 *	0.0664	-0.5572 *	0.0751
Retiree employer hl. Ins. (d)	-0.7281 *	0.1385	0.4256 **	0.0692	0.3912	0.0772
Commercial hl. Ins. (d)	0.0267	0.1526	-0.1142 *	0.0563	-0.0855 *	0.0610
Bequest motive						
Children 17 or younger (d)	0.7689 *	0.1587	-0.1719 **	0.0703	-0.2693	0.0847
Number of Children	0.0067	0.0277	0.0241 ***	0.0103	0.0190 **	0.0122
High bequest import. (d)	0.0820	0.1330	-0.0923 *	0.0517	-0.1389 **	0.0598
High bequest prob. (d)	-0.3206 ***	0.1642	0.2156 *	0.0631	0.1616 *	0.0685
Demographic						
Education (year of)	0.0737 *	0.0237	0.0362 *	0.0089	0.0365 *	0.0109
Married (d)	-0.2868 **	0.1307	0.0737	0.0524	0.1564 **	0.0636
White (d)	0.2487 ***	0.1366	0.0788	0.0528	0.0414	0.0624
Born in U.S. (d)	-0.3888 **	0.1915	0.2073 **	0.0827	0.1921 **	0.0964
Myopic (d)	-0.3535 *	0.1252	0.1213 *	0.0456	0.0617	0.0532
Job						
Self-employed (d)	1.5688 *	0.1865	-0.1550 *	0.0584	-0.2414 *	0.0648
Tenure (current job)	-0.0615 *	0.0053	0.0244 *	0.0021	0.0228 *	0.0023
Industry: manufactory, transport (d)	0.0531	0.2034	0.0990	0.0771	0.0723	0.0871
Industry: service (d)	0.2219	0.2039	0.1247 ***	0.0741	0.1432 ***	0.0841
Industry: prof. svc & pub admin. (d)	-0.0381	0.2125	-0.0201	0.0818	-0.0753	0.0932
Occupation: skilled (d)	0.3338 **	0.1537	0.0282	0.0594	0.0371	0.0663
Occupation: semi_skilled (d)	0.1234	0.1435	0.1377 **	0.0544	0.0630	0.0614
Constant	48.9816 *	1.0870	-3.7125 *	0.4505	-3.0902 *	0.5899
	Number of obs	4451	Number of obs	7206	Number of obs	5600
	F	89.93	Log likelihood	-2501.14	Log likelihood	-1987.63
	Prob > F	0.000	LR chi2	2482.94	LR chi2	1875.08
	R-squared	0.387	Prob > chi2	0.000	Prob > chi2	0.000
	Adj R-squared	0.383	Pseudo R2	0.332	Pseudo R2	0.321
	Root MSE	3.411				

Model 3 excludes the highest discount groups.

(d) dummy variable
* significant at 1% level
* * significant at 5 level
*** significant at 10% level

Figure 1
Participants in Pension Plans, Number of Pension Plans, and Pension Plan Assets by type of plan, 1975-99



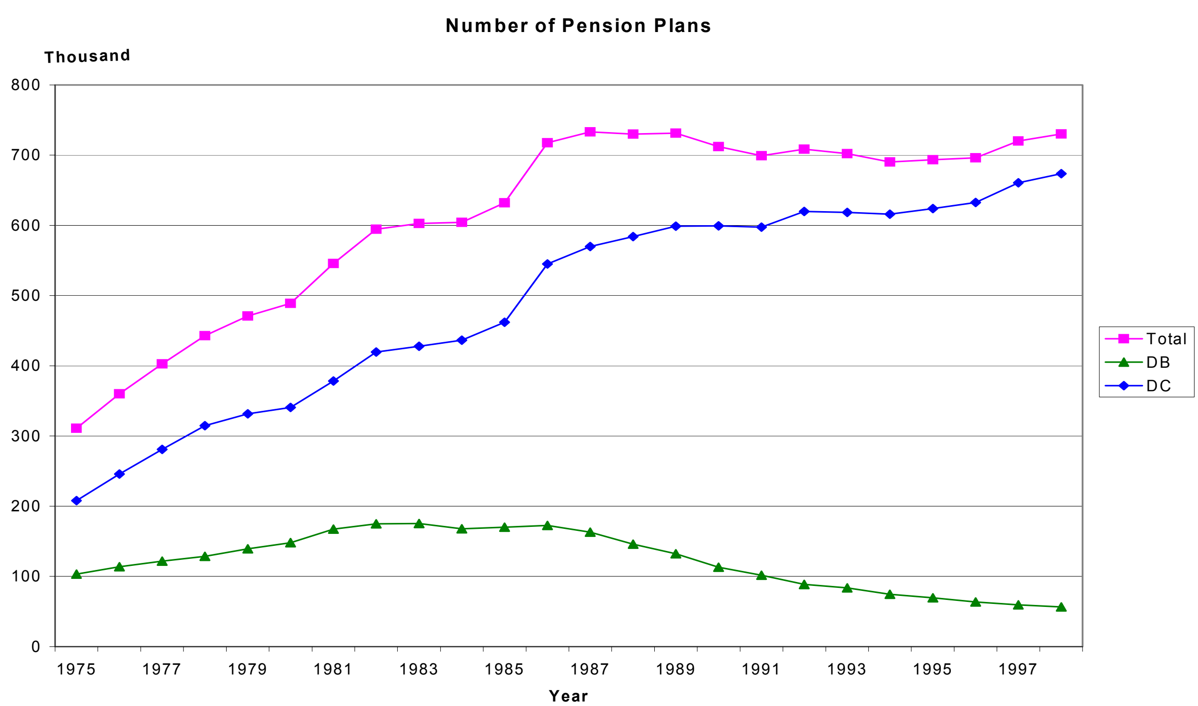
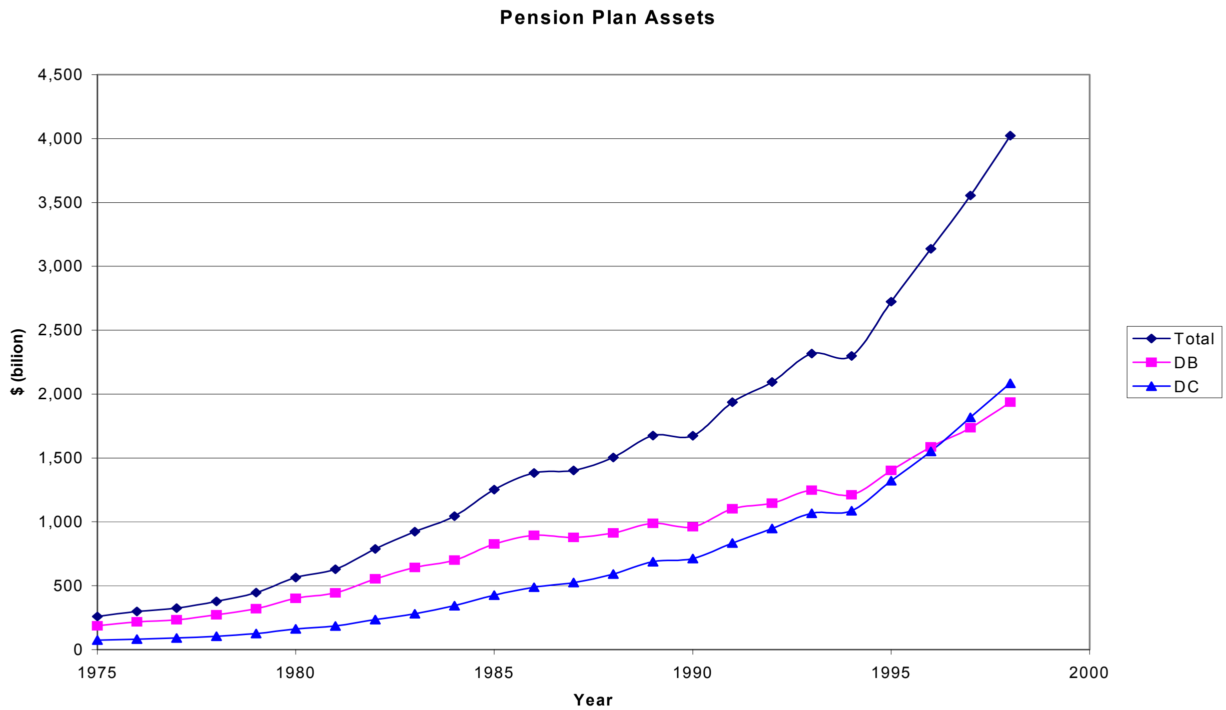


Figure 1 (Continued)

Participants in Pension Plans, Number of Pension Plans, and Pension Plan Assets, 1975-1999



Year	Participants in Pension Plans Total	DB	DC	Number of Pension Plans Total	DB	DC	Pension Plan Assets Total	DB	DC
1975				311,094	103,346	207,748	259,963	185,950	74,013
1976				359,980	113,970	246,010	298,440	216,283	82,157
1977				402,627	121,655	280,972	325,074	233,609	91,465
1978				442,998	128,407	314,591	377,195	272,684	104,511
1979				470,921	139,489	331,432	445,430	319,595	125,835
1980	48,986	30,100	18,886	488,901	148,096	340,805	563,551	401,455	162,096
1981	50,770	30,043	20,727	545,611	167,293	378,318	628,916	444,376	184,540
1982	53,099	29,678	23,421	594,456	174,998	419,458	788,986	553,419	235,567
1983	57,680	29,878	27,802	602,848	175,143	427,705	923,470	642,359	281,111
1984	60,918	30,373	30,545	604,434	168,015	436,419	1,044,591	700,669	343,922
1985	62,063	28,895	33,168	632,135	170,172	461,963	1,252,739	826,117	426,622
1986	63,057	28,529	34,528	717,627	172,642	544,985	1,382,910	895,073	487,837
1987	63,280	28,427	34,853	733,029	163,065	569,964	1,402,488	877,269	525,219
1988	61,912	27,966	33,946	729,923	145,952	583,971	1,503,635	911,982	591,653
1989	60,997	27,136	33,861	731,356	132,467	598,889	1,675,597	987,971	687,626
1990	61,545	26,205	35,340	712,307	113,062	599,245	1,674,140	961,904	712,236
1991	61,211	25,603	35,608	699,294	101,752	597,542	1,936,271	1,101,987	834,284
1992	63,898	25,222	38,676	708,335	88,621	619,714	2,094,087	1,146,798	947,289
1993	64,394	24,986	39,408	702,097	83,596	618,501	2,316,272	1,248,180	1,068,092
1994	64,607	24,480	40,127	690,344	74,422	615,922	2,298,556	1,210,856	1,087,700
1995	65,598	23,395	42,203	693,404	69,492	623,912	2,723,736	1,402,079	1,321,657
1996	67,470	23,133	44,337	696,223	63,657	632,566	3,136,281	1,585,397	1,550,884
1997	70,270	22,619	47,651	720,041	59,499	660,542	3,553,756	1,735,604	1,818,152
1998	72,835	22,863	49,972	730,031	56,405	673,626	4,021,850	1,936,600	2,085,250
1999	73,020	22,630	50,390						

U.S. Department of Labor, Private Pension Plan Bulletin: Abstract of 1999 Form 5500 Annual Reports, 2004

ACLI, Life Insurance Fact Book

Figure 2a
Male Labor Force Participation Rates by Age, 1950-1998

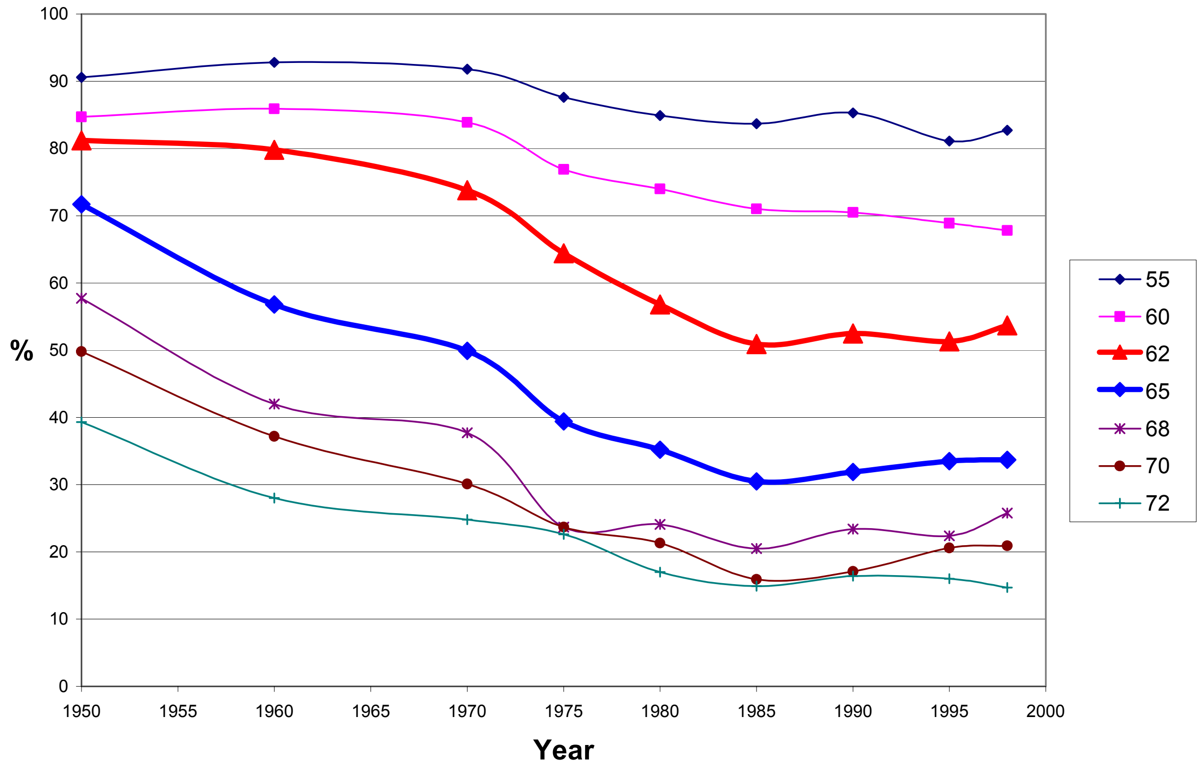


Figure 2b
Male Labor Force Participation Rates by Age, 1950-1998

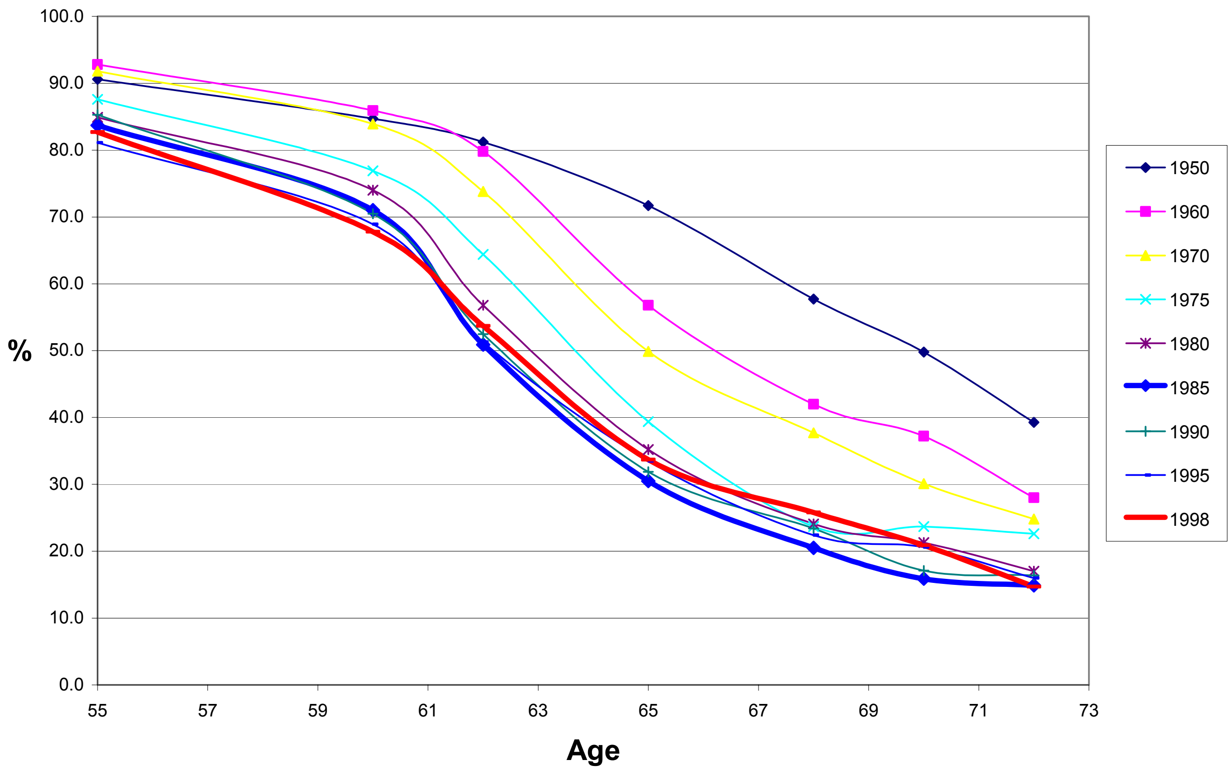
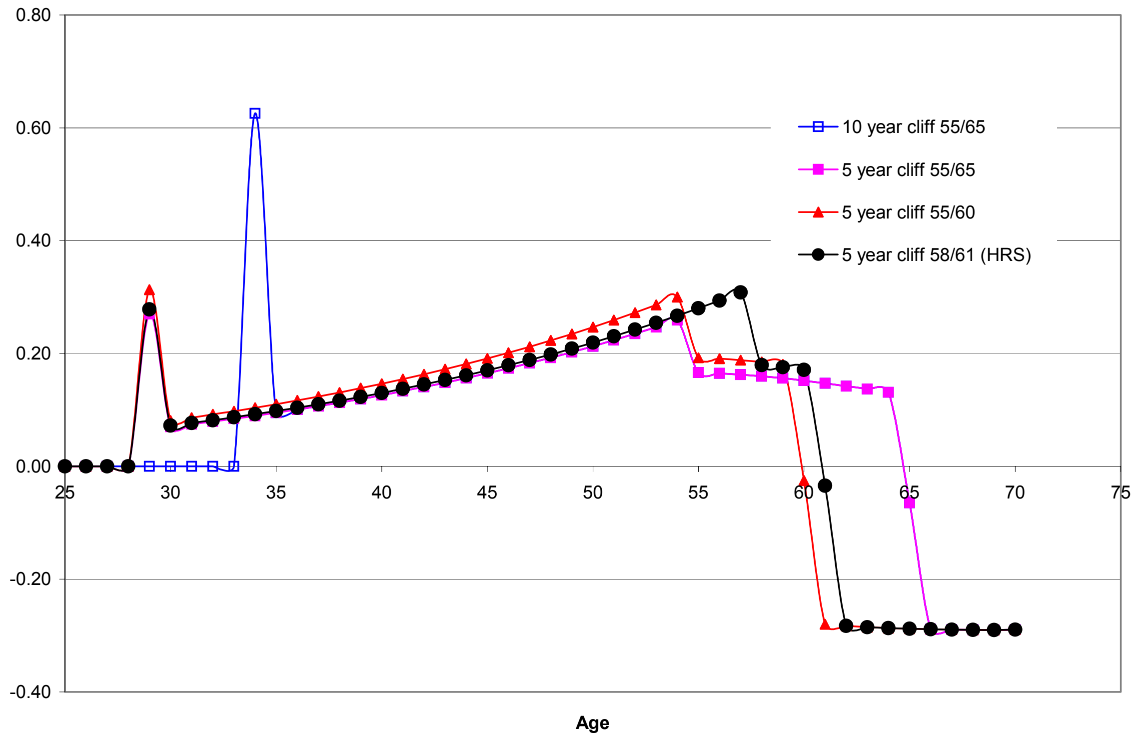


Figure 3
Pension accruals as the ratio of pension accruals to wage at each age



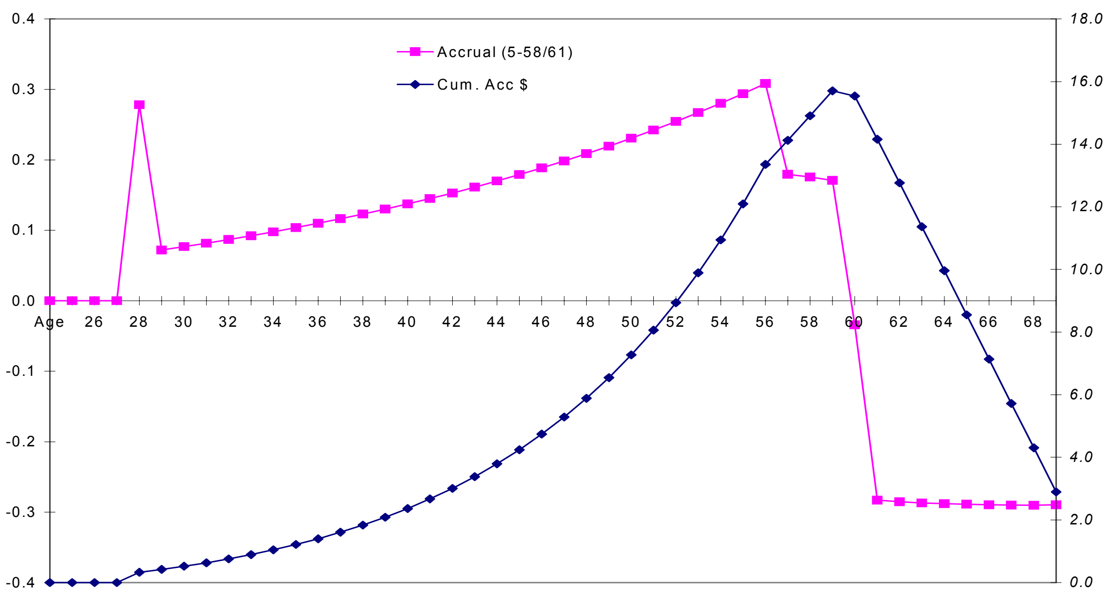


Figure 4
Hazard Functions