Essays on the U.S. Social Security Disability Insurance System

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Abstract of the Dissertation

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The Social Security Disability Insurance (DI) program is the primary public long- term disability program for disabled workers in the United States. It provides cash benefits and health insurance to workers with substantial losses in earning capacities due to severe health limitations. The fast growth of the DI rolls in the last few years and the increasing financial pressure on the Social Security system make improving work incentives among the disabled one of the most important policy goals for the Social Security Administration. In my dissertation, I explore the possibility of implementing a partial disability system in the United States.

The current DI program is an all-or-nothing system and awards benefits only to full disability, not to those partially disabled. That is, eligibility for DI benefits depends on demonstration of inability to work above a low earnings threshold defined as Substantial Gainful Activity (SGA) level. The strong work

disincentives created by the strict binary disability concept of DI program have been criticized. Under a partial DI system, partial disability benefits recipients will be able to engage in gainful employment while receiving disability benefits and supplement their work earnings with partial disability benefits. A partial Disability Insurance system amounts to essentially changing the current DI system from one that awards benefits only to those *fully disabled* (who have health limitations that prevent them from working completely) to one that awards also partial benefits to those *partial disabled* (whose health limitations interfere with their work but not prevent them from working completely) and are employing their *residual* work capacities in the labor force, and changing the Social Security definition of disability from a binary disability definition to a relatively continuous disability concept.

In the first essay, I solve and simulate a life-cycle model that characterizes detailed Social Security rules on DI and Old Age programs. The model is then used to predict the behavioral responses to a Partial Disability Benefit system that allows individuals to combine wage earnings with disability benefits. The appeal of this policy hinges on the possibility of inducing applicants to self-select themselves into a given disability level, while maintaining those with some residual work capacity in the labor force, and therefore keep them contributing through their labor taxes to the Social Security system, easing the budgetary pressures of the overall Social Security system. The current dichotomous definition of disability can result in relatively productive individuals dropping from the labor force to receive benefits in order to have access to a total income high enough to make ends meet. Instead, the new system will establish a culture of continuous attachment to the labor force in the wake of health limitations. The simulation results show that there will be significant increases in both DI applications and DI rolls under the Partial DI system, therefore the induced entry effect is expected to be large; however, most of the increases are due to increased applications for *partial* benefits and awards to *partial* benefits. In fact, applications for *full* DI benefits will decrease by 36.8 percent in the simulations, and *full* DI benefit rolls will drop by 24.2 percent. The mean duration spent on DI program will decrease dramatically from 14.4 years to 7.6 years. The budgetary and welfare calculation shows that the Partial DI system, under some conditions, can result in financial savings for the DI program as well as significant improvements in individuals' welfare.

One issue that has not been accounted for in the life-cycle model is the health insurance value of the DI program. There has an extensive literature addressing the incentive effect of *cash benefit* levels on disability application behavior. Although Medicare coverage is believed to be an important motive for disability applicants, it is almost impossible to study the effect of its value variation across states on the disability application, for Medicare is a nationally-administered program. Without measuring the value of this in-kind benefit, any estimation of the effect of DI benefits on application behavior will be biased upward. In the second essay, I take a new look at the elasticity of disability application behavior to DI cash benefit levels by exploiting the little-noted fact that DI application of the 62-64 years old is driven by disability cash benefits only and Medicare coverage can not be the reason for these ages to apply for disability. Taking advantage of this special age window from 62 to 64, I am able to more precisely estimate the incentive effect of cash benefit levels on disability application behavior without worry about the possible bias caused by Medicare incentives of disability application since Medicare incentives do NOT exist in this age window. In particular, DI program grants Medicare coverage to disability awardees only after two years since the date of award. Thus, the 62-64 years old disability applicants, if approved, will be granted cash benefits immediately, but will be extended the Medicare coverage only after two years being on the disability roll, at which point they will be at age 65 or older when Medicare coverage is available to everybody, regardless of DI application. I infer that cash benefits offered by DI program are the main driving power for the application of the 62-64 years old. Thus, estimating the response of disability application decisions to DI cash benefit levels on this specific age window 62-64 is a natural way to separate out cash incentive effect (from health insurance effect) of DI application and get more precise estimation results than previous literature.

Disentangling cash benefits incentives and health insurance incentives of disability applicants is informative for policymakers. The Social Security Administration (SSA) has implemented a series of policy changes since the inception of the DI program. Some make use of financial incentives of DI applicants and beneficiaries to implement policy goals and others are devoted to understanding health insurance motives for DI application and participation. Nevertheless, the effects of those two types of policy changes on DI application and participation have been very difficult to differentiate. Separating cash incentives effect from health insurance incentives effect of disability application is informative for policymakers to evaluate the effectiveness of disability policy reforms.

Not surprisingly, I find lower elasticity of application with respect to disability cash benefit level changes than the estimates in previous literature. Of course, the 62-64 years old are the oldest possible DI applicants. Their responsiveness to benefit changes can only be regarded as a lower bound of the cash elasticity of disability application in general. The fact that this group do respond to benefit changes confirm that cash value of DI program can be significant in general. The previous studies focus on younger applicants than the sample in my study but do not usually model the Medicare values of DI program, which make their results an overestimates of DI program's cash value in application decisions.

献给我亲爱的妈妈爸爸，
翠英和正伦

To my loving parents,
Liu Cuiying and Yin Zhenglun

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Chapter 1

Partial Benefits in the Social Security Disability Insurance Program: A Policy Alternative to Foster Work among the Disabled

1.1 Introduction

The Social Security Disability Insurance (DI) is the primary public long-term disability insurance program for disabled labor force participants in the United States. It is designed to insure against substantial losses in earnings capacity due to severe health problems that are expected to last at least 12 months or result in death. According to the Social Security Administration (SSA) Trustee annual report, more than 93 billion dollars of DI benefits are paid to 9.5 million people in

2006. The program has grown significantly over time. There has been an increase of 93% from 1990 to 2006. As the baby boomers reach the age of increased probability of disability the growth in the disability program is likely to be faster. The SSA projects that from now until 2012 the number of DI beneficiaries will increase by 37%. In addition, the increasing life expectancy raises the person-years of the DI roll. The projected growth of the DI program endangers a policy system that is already inadequate to meet the needs of the public. Since both Social Security Old Age program and DI program are funded by Social Security payroll tax, the SSA trustee predicts that the fast growth of DI program will soon necessitate a reallocation of the Social Security contribution between the DI and Old Age programs. Therefore, improving work incentives among the disabled has become increasingly important on the policy agenda.

The current US DI program is an all-or-nothing system. That is, the DI applicant will either receive *full* DI benefits if accepted, or receive *zero* benefit if rejected. In other words, the program implements a definition of "*full* disability": eligibility of the program depends on demonstration of *complete* loss of work capacity. Inherent work disincentive in the dichotomous disability definition has been recognized by policy makers. In a report from the Social Security Advisory Board (2003) on the Definition of Disability, it is said,

[…] *as long as benefit receipt is conditional on demonstrating a lack of ability to work, disincentives will be inherent to the system*.

The current Social Security disability definition, a binary indicator, coupled with the restrictions on work once on the rolls, is very likely to result in high welfare costs for those that retain some work capacity but cannot rely solely on their work earnings to make ends meet. Instead of being a binary concept, disability by its nature is a continuous variable. The disability program should mirror the reality of disability status.

In fact, policy makers have considered a policy alternative, a partial disability system. In a report prepared by the Social Security Advisory Board (2006), their suggestions for long-term disability program enhancements include "*Consider a partial disability program - One concept that has been brought to our attention is that of establishing eligibility criteria for 'partial disability.*'" In an earlier report (2003), one of the alternative program changes they suggest is "*changing the current all-or-nothing concept of disability eligibility to a program providing percentages of disability based (at least for less than 100 percent levels) on very specific medically determinable criteria*."

In the paper, I explore the possibility of setting up a partial Disability Insurance in the US system where individuals self-select themselves into a given disability level, for example, 25%, 50%, 75%, and 100%, where the last category would be equivalent to the current definition of disability.

Under a partial DI system, partial disability benefits recipients will be able to engage in gainful employment while receiving disability benefits and supplement their work earnings with partial disability benefits. A partial Disability Insurance system amounts to essentially changing the current DI system from one that awards benefits only to those *fully disabled* (who have health limitations that prevent them from working completely) to one that awards also partial benefits to those *partial disabled* (whose health limitations interfere with their work but not prevent them from working completely) and are employing their *residual* work capacities in the labor force, and changing the Social Security definition of disability from a binary disability definition to a relatively continuous disability concept.

Introducing the partial benefits option into the DI program is new in the United States, but it is not unusual in many OECD countries where the public contributory disability program pays partial benefits as well as full benefits to disability recipients (see appendix for a list of some OECD countries with partial DI system). All those partial disability programs try to ensure that the disabled participate in the labor force as fully as possible and not be driven out of labor force too early, while providing them with income security.

1.1.1 Can the disabled work?

Before we talk about keeping the disabled in the labor force, it is a valid question to ask whether they are able to work. A lot of research has explored the relationship between the growth of DI rolls and the decrease of labor force participation among the disabled (Gastwirth, 1972; Swisher, 1973; Bound and Waidmann, 1992; Autor and Duggan, 2003, 2006, 2007). Although the magnitudes of the estimates vary across studies, they all find some impact of the existence of DI program on the disabled leaving the labor force. For example, some literature has estimated the elasticity of DI benefits levels on the labor force participation among the disabled (Parsons, 1980; Slade, 1984; Haveman and Wolfe, 1984; Halpern and Hausman, 1986; De Jong et al., 1988; Haveman et al., 1991; Danzon, 1993; Gruber, 1996; Kreider, 1999; Kreider and Riphahn, 2000). The elasticity estimated varies from 0.21 to as high as 0.93 depending on the sample and health measures used. The employer accommodation has also been argued to be important in keeping disabled individuals in the labor force (Burkhauser et al., 1996, 1999, 2001/2002, 2004). Moreover, relatively high wage uncertainty is argued to drive the disabled out the labor force and applying for disability benefits (Kreider, 1998). Economic conditions are also found to have impacts on DI applications (Rupp and Stapleton, 1995; Stapleton and Dietrich, 1995; Stapleton, 1998).

Not only the disability benefits applicants are found to have residual work capacities, but also the disability beneficiaries are inferred to retain some work abilities (Bound, 1989; Maestas and Yin, 2008). Some studies calculating the classification errors of the DI program also imply that DI beneficiaries are still able to work (Nagi, 1969; Smith and Lilienfeld, 1971; Benítez-Silva et al., 2004).

1.1.2 Policy changes of improving work incentives among the disabled

A partial DI system is consistent with the SSA's policy efforts to improve work incentives among the disabled. All the disability policies have two general goals: one is to insure the disabled individuals against earning losses and have economic security; the other is to encourage the disabled to participate as fully as possible in the labor market. Those are also what we call equity and efficiency objectives. Since DI benefits are financed through payroll tax, the lower the employment rate, the lower the Social Security contributions. Therefore, how to reconcile those two seemingly contradictory goals and foster work among the disabled has been important to policy makers.

The SSA has implemented many policy changes to improve the work incentives among the disabled since the inception of the DI program: Trial Work

Period (TWP), Continuing Disability Reviews (CDR), Extended Period of Eligibility (EPE), Expanded Availability of Health Care Services, Expedited Benefits, Disability Reviews Postponed, Project ABLE, Project RSVP, Americans with Disabilities Act (ADA), Work Incentives Improvement Act of 1999, Tickets to Work and Self-Sufficiency Program, etc. Recently, the SSA has continued the policy trial with objective of fostering work among DI recipients. However, all the above efforts have not resulted in an increase in the termination rates of the DI rolls, compared with, for example, the year 2001. Except those leaving the rolls due to death or conversion to the Social Security rolls, the termination rate during 2006 due to medical recovery is as low as 0.4 percent among the 6.5 million who were disabled worker beneficiaries in 2005 (0.43 percent in 2001), and the termination rate due to earnings higher than the exempt amount, or substantial activity levels, is only 0.55 percent (0.58 percent in 2001).

It is worth noticing that one of the most promising policy changes under consideration of the SSA now, internally termed as the "$1 for $2 benefit offset",[1] intends to foster work among DI recipients. That policy proposal is essentially an *ex post* partial Disability Insurance system. It offers "partial benefits" to the disabled who are still on the DI rolls and return to work, by allowing beneficiaries to keep their benefits while returning to work but imposing a 50% tax rate on their

[1] See Benítez-Silva et al. (2006) for discussion of the policy change and forecast of behavioral responses to that policy change.

earnings above a threshold level. In contrast, the partial Disability Insurance system discussed in this paper, essentially an *ex ante* partial DI system, provides partial benefits options to the DI applicants who can exert their residual work capacities and still engage in gainful activities.

One possible problem with the $1 for $2 reform is that it focuses on the current disability recipients and maintains a possibly inconsistent DI system where in order to get into the program you have to be fully disabled, but as soon as you are in the program, it is accepted that your disability is only partial. While it makes sense to accommodate health improvements, it clearly opens the door for more strategic behavior. In this paper we consider another policy reform, the *ex ante* partial Disability Insurance system, which should not necessarily be considered a substitute to the ones we have already described. The "$1 for $2 benefit offset", an *ex post* partial benefits system, together with the *ex ante* partial benefits system we explore in this paper, would make the DI program a "symmetric" system to avoid opportunistic behavior and foster continuous attachment to the labor force among the disabled.

1.1.3 Early intervention policies to maintain the disabled in the labor force

A partial DI system can be an integral part of early intervention policies. Early intervention policy, a “screening” procedure of the disability program, intends to maintain in the labor force as many disabled people as possible who still have residual work abilities, before they go to apply for disability benefits. A partial DI system intends to keep in the labor force disability applicants who are still able to do some work by providing them with partial disability benefits to supplement their work earnings.

Some researchers (Burkhauser et al., 1996, 1999, 2001/2002, 2004) examine the effect of one of the early intervention policies, the employer accommodation, on disabled workers’ decisions to apply for DI benefits. After the onset of disabling conditions, the worker who still has residual work capacity might choose to keep working if the employer provides him necessary accommodation, therefore employer accommodation might “screen” some disabled workers who would otherwise apply for disability benefits. However, the great heterogeneity of job characteristics, employers’ characteristics, and costs to provide accommodation makes the effect of this type of early intervention difficult to evaluate.

In fact, a partial DI system can act as part of the "screening" procedure: if the disabled worker eventually decides to apply for disability benefits after the onset of disability and maybe even after the failure of being provided employer accommodation, a partial DI system would be able to "screen" those disabled applicants who are still capable of engaging in some gainful activities by keeping them do so while offering them partial disability benefits supplemental to their earnings. Moreover, a partial benefits system as an early intervention might help keep people with disabilities from seeing their Human Capital depreciate too quickly. Some researchers have been concerned with the fact that disability benefits applicants might lose Human Capital and work skills since under the current system, the applicant has to leave labor force almost completely in order to be eligible for the benefits and there is a long waiting period before the SSA determination is made.[2] A partial DI system as an early intervention might prevent disabled workers from completely disconnecting with the labor market and losing Human Capital because the system allows the disabled worker to engage in gainful activities while applying for DI benefits and while receiving disability benefits.

[2] On average, the waiting period is one year, that is, the five-month mandatory waiting by the DI program and about seven-month waiting for the decisions of the SSA. If taking into account the appeal stages, the waiting time can be even longer.

1.1.4 Policy changes in DI affect Social Security retirement program

Any reform that fosters work among disabled individuals can be an important part of a successful reform of the Social Security Old Age (OA) program. DI benefits act as a "bridge" to fill in the gap between earning losses due to early withdraw from the labor force caused by severe work limitations and OA benefits. Any reform on OA program is likely to have important effects on the application and receipt of DI benefits. For Example, increasing the Normal Retirement Age from 65 to 67 might imply that disabled workers could stay on disability rolls for two more years before converting to retirement program (Duggan et al., 2007). In addition, the baby boomers reach the ages of higher probability to develop disabilities, which makes it increasingly important for the SSA to reform the DI program.

1.1.5 Induced entry effect of the DI reform

It is natural to be concerned with the induced entry effect possibly caused by a partial benefits system, since this option makes the program more generous and therefore induces more applications to the DI program and results in increases in the program administrative cost and caseload. It is true that under the proposed partial benefits system, under some conditions, everybody who is applying now would still apply, and some individuals who do not apply now would probably do so since their partial disabled conditions would qualify for getting benefits. On the other hand, there are some individuals who apply for disability benefits now because their health problems and work limitations prevent them from supporting themselves solely on their work earnings. For them, applying for disability benefits becomes a rational (maybe unique) choice. The partial benefits system allows these individuals to self-select themselves into a given disability level (defined by disability benefits levels) and receive partial disability benefits in addition to their work earnings, which could likely result in savings for the SSA.

The total incurred costs for the government of changing current Full DI system to a Partial DI benefits system will be determined by the following:

Total cost = Increased Partial benefit payments – Decreased Full benefits payments – Increased Social Security Payroll Tax and Federal Income Tax due to increased labor force participation

In the expression above, partial benefit payments are paid to two groups of individuals: i) those who are not eligible for current full DI benefits while under a partial DI system are induced to apply for partial disability benefits (induced entry effect); and ii) those who could have been forced to leave the labor force and apply for full DI benefits under the current system while under a partial DI system will take the option to apply for partial DI benefits as a complement to their work earnings. The increased labor force attachments under a partial DI benefits system will raise the Social Security payroll tax and the Federal Income tax. It is theoretically possible, under some conditions, to implement a partial disability system that despite a potential induced entry effect, see a decline in the costs of the system.

I explore those conditions, using a life cycle model, and relying on the empirical information provided in the HRS data and some aggregate level data produced by the SSA and other sources, to assess the size of the populations at risk of being affected by this policy change.

The outline of the paper in as follows. In section 2, I summarize the rules of the DI program. In section 3, I outline the specifications of the benchmark model that characterizes current DI program and a partial DI model. Section 4 describes the data we use and discuss the calibration of our benchmark model to the data. Section 5 summarizes our simulation results. Section 6 concludes and outlines possible extensions of the paper.

1.2 Social Security Disability Insurance program

The Social Security Disability Insurance is a social insurance program that insures workers against substantial losses in earnings capacity due to severe health problems. The program is financed by the Social Security payroll taxes. To be eligible for DI benefits workers must be determined to have a medically determinable physical or mental condition that has lasted or is expected to last at least 12 months or result in death, and that prevents them from engaging in any substantial gainful activity (SGA). The SGA level is automatically adjusted annually based on increases in the national average wage index. Current SGA level is $900 per month.[3] The disability determination of the initial claim is made through a five-stage sequential process (See appendix for details). DI only provides benefits to fully disabled applicants. No partial benefits are provided. That is, the award will be given only to those applicants who are determined unable to engage in *any* substantial gainful activity in the whole national economy due to severe disability conditions, taking into account the individual's age, education, and employment history.

[3] The SGA level for the blind is $1,400 per month.

Disability awardees start to receive their monthly benefits (Primary Insurance Amount, PIA) after five months since the date of being awarded. The PIA is based on workers' insured earnings history, summarized in the Average Indexed Monthly Earnings (AIME). The formula to calculate the PIA from the AIME for cohorts who reach age 62 or become disabled in 2007 is[4, 5]

$$PIA = \begin{cases} 0.9 * AIME & \text{if } AIME < 680 \\ 0.9*680 + 0.32*(AIME - 680) & \text{if } 680 \leq AIME \leq 4{,}100 \\ 0.9*680 + 0.32*(4{,}100 - 680) + 0.15*(AIME - 4{,}100) & \text{if } AIME > 4{,}100 \end{cases}$$

DI benefits may be terminated for several reasons. In some cases, beneficiaries' health conditions improve and they return to work. In other cases, they are found to be capable of SGA by the Continued Disability Review (CDR).

Different with the decision to apply for retirement benefits, the decision to apply for DI takes into account the uncertainty of being rejected. Eligibility to

[4] We use the 1992 formula in the model because the model is calibrated to the HRS cohorts.

[5] The Social Security OA program provides benefits to covered workers and their eligible dependents and uses the same formula as DI program to compute benefits. The retirement benefits for a covered worker who is qualified by having worked for forty quarters are calculated as following: the average of the highest 35 years of earnings, indexed by national average earnings, is divided by 12 to get the AIME; then a piece-wise linear progressive function converts the AIME to the PIA. The Early Retirement Age (ERA) has been 62 until now. While the Normal Retirement Age (NRA) has been legislated to increase gradually from 65 to 67, that is, for the cohort born in 1938 and later the NRA is scheduled to increase by two months with every cohort until it reaches 67 for the cohort born in 1949 and later. An individual who retires at the NRA will collect 100% of the PIA. Individuals who retire between the Early Retirement Age (ERA) and the NRA can collect only a reduced PIA by an actuarial reduction factor (ARF), which is equal to $5/9^{th}$ of 1% per month for the first 36 months after claiming before the NRA, and $5/12^{th}$ of 1% per month for the months after those first 36 months. Individuals who retire after the NRA can increase their benefits through delayed retirement credits (DRC) and are able to collect benefits more than 100 percent of their PIA. The DRC is scheduled to increase gradually until 8% for each year of delay. See Benítez-Silva and Yin (2007) for a detailed discussion on the ARF and the DRC.

both depends on work history, however, retirement eligibility is based on age and thus is easy to determine whereas eligibility for DI is harder to decide. Application to DI can be just the beginning of a sequential eligibility process and a protracted appeals process whose final outcome is uncertain (Benítez-Silva et al., 1999). The probability that an application for DI is approved has varied dramatically over time and across states (Benítez-Silva et al., 2004; Yin, 2004).

1.3 The Model

1.3.1 Benchmark Model

1.3.1.1 Model Specification:

The individual in the model is assumed to be a single male. An individual is assumed to make choices on consumption, labor supply, and Social Security application in each period to maximize the expected present value of his utility over his life time.

Time. In the model, time *t* is discrete and each period is one year. We start our model from age 21 when we assume that an individual begins to decide whether or not to enter the labor force. There is a finite horizon, age 100, when death is certain. We solve the model over 80 periods and $t = \{0,1,...,79\}$, where t=0 indexes age 21, t=1 indexes age 21, ..., t=79 indexes age 100.

Health and mortality. Health status, indexed by h_t, is assumed to be exogenous. h_t=0 denotes good health; h_t=1 denotes being partially disabled; and h_t=2 denotes being fully disabled. Survival probabilities $\pi_t(age, h_t)$ in the model estimated from the Health and Retirement Study (HRS) includes only those of aged above 50 or so. Then I use the death rate from 2003 United States Life Table for younger people and adjusted it in an ad hoc way according to the proportion of different health status, indexed it off from the basic survival probability in the Life Table. To be consistent, I just use the health adjusted mortality rate based on the Life Table for all the ages. And the weighted death rates according to health distribution in the HRS data for age above 50 are very similar to the ones in the Life Table. Table 1.4 summarized the mortality rates by age and health status. My experiments show that using health adjusted mortality rate or only age-specific mortality rate does not affect the model result at all. Nardi, French and Jones (2006, page 32-33) also shows the similar result. The survival probabilities used in the model are age and health specific. Not surprisingly, the results show that survival probabilities decrease as age increases and health deteriorates.[6]

Labor supply. An individual makes decisions on how much to work in each period. We define labor supply (leisure) a discrete choice variable in the model. The probability of being laid off or becoming unemployed is not modeled. Compared to the three categories that most of life-cycle models use to define the discrete labor supply choice, Full-time Work, Part-time Work, Not Work, we refine the leisure choice into five levels to get a less lumpy and smoother employment profile. An individual is assumed to have 12 hours awake per day to allocate between leisure and work. One that works 2080 hours per year[7] is defined

[6] Of course we should always keep in mind while interpreting the predicted results of a model that reliability of current mortality rate and assumption of future mortality projection are critical to make sound policy planning and prediction.
[7] We assume that an individual works 40 hours per week and 52 weeks per year.

as Full-time Working and the proportion of awake time she allocates to leisure per year is l_t = 0.525. The other levels of leisure are proportional to the full-time worker's leisure. We summarize the leisure levels as follows:

Leisure Levels l_t	Label	Work hours	Derivation
0.525	Full-time Work	2080 hrs / yr	$l_t = (12*365-2080)/(12*365) = 0.525$
0.644	Part-time Work (75-percent of Full-time)	1560 hrs / yr	$l_t = (12*365-1560)/(12*365) = 0.644$
0.763	Part-time Work (50-percent of Full-time)	1040 hrs / yr	$l_t = (12*365-1040)/(12*365) = 0.763$
0.881	Part-time Work (25-percent of Full-time)	520 hrs / yr	$l_t = (12*365-520)/(12*365) = 0.881$
1.0	Not Work	0 hrs / yr	$l_t = (12*365-0)/(12*365) = 1.000$

Social Security. Let ssd_t be the Social Security decision of an individual at period *t*. This choice variable takes three values: ssd_t=1 when an individual chooses to claim Social Security retirement benefits (Social Security Old Age benefits, or OA benefits); ssd_t=2 when she decides to apply for DI benefits; ssd_t=0 denotes applying neither of the programs. People have different Social Security choice sets at different ages, as shown in the table below.

Age	Social Security Choice Set
age < ERA	$ssd_t \in \{0,2\}$
ERA $\leq$ age < NRA	$ssd_t \in \{0,1,2\}$
NRA $\leq$ age < MRA	$ssd_t \in \{0,1\}$
age $\geq$ MRA	$ssd_t \in \{1\}$

In the table, the cutoff ages for different choice sets are Early Retirement Age (ERA), Normal Retirement Age (NRA), and Maximum Retirement Age (MRA). The ERA, age 62, is the earliest age individuals can claim their Social Security Retirement benefits. The early retirement benefits are subject to an actuarial reduction. We set the NRA at age 66 in the model, which will be the one in effect starting in 2008 up to 2017. The distribution of the NRA of the HRS sample and the SSA rules to calculate NRA based on years of birth can be found in Appendix. At the NRA, retirement claimers receive the full OA benefits, which are calculated based on their earnings histories. Individuals who claim OA benefits after their NRA will get Delayed Retirement Credits (DRC).

The dynamic decision problem of applying for Social Security benefits is illustrated in Figures 1.1-1, 1.1-2, 1.1-3, and 1.1-4. An individual can apply for DI benefits at any age before her NRA. [8] We do not model the appeal process here

[8] The DI rules for younger applicants are a bit different. Eligibility for benefits under the OASDI program requires some minimal level of work in covered employment. This requirement is established by a worker's accumulation of quarters of coverage (QCs). Prior to 1978, one QC was credited for each calendar quarter in which at least $50 was earned. In 1978, when quarterly reporting of earnings was replaced by annual reporting, the amount required to earn a QC (up to a maximum of four per year) was set at $250. Since then, this amount has been adjusted each year according to changes in the AWI. Its value in 2007 is $1,000. There are three types of insured status which can be acquired by a worker under the OASDI program. Each of these statuses is determined by the number and recency of QCs earned. Fully insured status is acquired by any

and assume that a rejected DI applicant re-applies instead of modeling appealing, since modeling appealing needs more states and it will increase exponentially the dimension of the dynamic problem that we are solving. Although we avoid some computation burden, we are very likely to over predict the initial application pool. If an applicant is awarded DI benefits and stays on the roll until her NRA, DI benefits will automatically convert to OA benefits. Between the ERA and the NRA, an individual has options to apply for both OA and DI benefits although her early OA benefits are subject to an actuarial reduction, as discussed earlier. Individuals aged between NRA and MRA have option to apply for only OA benefits if they have not done so by then and their OA benefits are increased through Delayed Retirement Credits. The MRA, age 70, is assumed to be an absorbing state and everybody is assumed to have already been on the retirement rolls by then, since there's no further gain by delaying claiming OA benefits after MRA, since the delayed retirement credit applies to up to age 70. Notice that the initial OA benefit claiming is an irreversible choice. That is, an individual cannot

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worker whose total number of QCs is greater than or equal to the number of years elapsed after the year of attainment of age 21 (and at least six). Once a worker has accumulated 40 QCs, he or she remains permanently fully insured. Disability-insured status is acquired by any fully insured worker over age 30 who has accumulated 20 QCs during the 40-quarter period ending with the current quarter; any fully insured worker aged 24-30 who has accumulated QCs during one-half of the quarters elapsed after the quarter of attainment of age 21 and up to and including the current quarter; and any fully insured worker under age 24 who has accumulated six QCs during the 12-quarter period ending with the current quarter. Currently insured status is acquired by any worker who has accumulated six QCs during the 13-quarter period ending with the current quarter. Periods of disability are excluded from the above described QC requirements for insured status (but do not reduce the minimum of six QCs).

leave the OA roll once she is on it, although the benefit can vary over time due to the earnings test and posterior adjustment for benefits lost due to the earnings test.

There are earning tests for both DI beneficiaries and OA beneficiaries. An eligible individual for receiving DI benefits cannot engage in any Substantial Gainful Activity (SGA), and the SGA earning threshold is currently $900 per month (we use annual amount $10,800 in the model). The implicit tax rate on earnings over the SGA level is 100 percent. That is, a DI applicant earning more than SGA level will be rejected, or a DI recipient with earning more than SGA level will lose her eligibility and be removed from the roll.[9] The implicit tax rate for OA beneficiaries aged between 62 and NRA is 50 percent on annual earnings over $12,960, while the implicit tax rate is 33 percent in the year reaching NRA on annual earnings over $34,440. [10] There's no earning limit for OA beneficiaries after their NRA.[11]

Both DI benefits and OA benefits are determined by the function $ssb_t = ssb(AIME_t,\ age_t,\ wage_t)$. Average Monthly Indexed Earnings (AIME) is the key variable used to compute the Primary Insurance Amount for both OA and DI benefits. (See Appendix for details of the formula.) Age was one argument in

[9] The SGA level is similar to the poverty line for a one-unit family. Since the earnings limit (SGA levels) for DI benefits are very low, a lot of times, roughly speaking, DI applicants or beneficiaries are said to be *unable to work at all* to be eligible for the program.
[10] The tax applies to only the months *before* reaching NRA in that year, not those months after NRA in that year.
[11] See Benítez-Silva and Heiland (2006, 2007), and Song and Manchester (2007), for a detailed discussion of the effects of the earning test on labor supply and retirement claiming behavior.

the benefit function because of two reasons: first, the first age when an individual claim OA benefits will decide whether she gets her full Primary Insurance Amount (PIA) or reduced PIA by actuarial adjustment factor or increased PIA by delayed retirement credit; second, earning tests for OA benefits are age specific. Wage earnings affect AIME computation and also the earnings test for both OA and DI benefits.

The approximation for the computation of AIME in the model is very close to Benítez-Silva et al. (2001). We have taken earnings records from 1951 to 1991 from the SSA restricted data. The AIME is calculated according to the SSA formula. A log-normal form is used to approximate the evolution of AIME:

$$\log(aw_t) = \alpha_0 + \alpha_1 \log(y_{t-1}) + \alpha_2 \log(aw_{t-1}) + \alpha_3 t + \alpha_4 t^2 + \varepsilon_t \quad (1)$$

where aw is the annual indexed earnings (aw = AIME * 12), y is annual earnings and t is age. R-square to this regression is close to 0.98. So given the above parameter estimates, the AIME at age t can be predicted relatively precisely as

$$\widehat{aw}_t = \exp(\hat{\alpha}_0 + \hat{\alpha}_1 \log(y_{t-1}) + \hat{\alpha}_2 \log(aw_{t-1}) + \hat{\alpha}_3 t + \hat{\alpha}_4 t^2 + \sigma_\varepsilon^2 / 2) \quad (2)$$

Wage is assumed to follow a log-normal distribution and is a function of aw.

$$\log(y_t) = \alpha_0 + \alpha_1 \log(aw_{t-1}) + \alpha_2 t + \alpha_3 t^2 + \eta_t \quad (3)$$

DI award probability $p_1(wage, h)$ is a function of wage and health status. If wage while applying is higher than the SGA level, the award probability becomes zero. Being disabled has a higher chance to be accepted than other two health status (good or poor).

There's also an audit probability for DI recipients, denoted by $p_2(h)$. It is the probability of being terminated from the DI roll and depends on health status. If a health improvement is expected from the awarded applicant, a review/audit will be conducted in six to eighteen months after the start of the benefits. If a health improvement is thought to be just possible, a review will not be conducted sooner than three years. If a health improvement is hardly expected, a review will not be done any earlier than seven years. We set $p_2(h=0)=0.05$, $p_2(h=1)=0.02$, and $p_2(h=2)=0.01$. That is, there is a 5 percent probability to be removed from the DI roll if one's health status is good, a 2 percent probability to be removed if one is in poor health and partially disabled, and still a 1 percent probability to be removed if one is fully disabled, according to the data.

The Social Security state variable ss_t takes ten values: ss_t=0 denotes not on any Social Security program, ss_t=62 – 70 denotes nine ages first entitled to OA benefits. To economize the computation burden, we use age and ss_t together to denote the state being on DI: ss_t=NRA and age<NRA. We are allowed to do

so because DI benefits are computed using the similar formula to OA benefits[12] and DI recipients can enjoy 100 percent of PIA before NRA while non-DI recipients can only receive 100 percent PIA at their NRA. We keep track of the age when one is first entitled to OA benefits because OA benefits are subject to different adjustments at different ages between 62 and 70, as discussed earlier.

Tax function $\tau(y_t, w_t)$. We include in our model the Social Security tax deducted from payrolls (15.75 percent), progressive federal income tax (the negative tax indicates the Earned Income Tax Credit, or EITC), and state and local income, sales and property taxes. Federal income taxes are also imposed on part of Social Security benefits when one's combined income (including Social Security benefits) is higher than some threshold.

Utility function. Instantaneous utility function takes the form:

$$u_t = (c_t^{\gamma} - 1)/\gamma + \phi(age, h_t, aw_t) * \log(l) - h - stigma(w_t, age_t) \quad (4)$$

if one applies for DI benefits;

$$u_t = (c_t^{\gamma} - 1)/\gamma + \phi(age, h_t, aw_t) * \log(l) - h \quad (5)$$

if one does not apply for DI benefits. $\phi(age, h_t, aw_t)$ is defined as disutility from work, which increases in age, decreases in average wage, and increases as health

[12] The difference between DI and OA benefits computation lies in the requirement of quarters of coverage and how the wage history is imputed while calculating AIME. Quarters of coverage are not modeled explicitly here.

gets worse. Health affects utility both directly and indirectly through its effect on disutility from work. We assume that stigma from applying for DI benefits exists and it increases in wealth and decreases in age.

Uncertainties in the model are from age and health specific survival probabilities, health transition, wage earnings, DI award probability, and DI audit probability.

1.3.1.2 Solving the Model:

The value function in period t is the expected present discounted value of remaining lifetime utility for an individual with state variables S_t and making optimal decisions from t onward until the end of life:

$$V_t(S_t) = \max_{D_t}\{u_t(S_t) + \beta * E_t V_{t+1}(S_{t+1} \mid S_t, D_t)\} \tag{6}$$

if one is alive at period t+1;

$$V_t(S_t) = \max_{D_t}\{u_t(S_t) + \beta * EB(S_{t+1} \mid S_t, D_t)\} \tag{7}$$

if one dies at period t+1.

The vector of state variables is

$$S_t = \{w_t, aw_t, ss_t, h_t\}$$

and the vector of decisions (choice variables) is

$$D_t = \{c_t, l_t, ssd_t\}$$

In the value functions (6) and (7), β is the discount factor. The vector of state variable S_{t+1} represents the state at the beginning of period t+1 after period t decisions D_t have been made and the uncertainties of period t+1 have been realized. The expected conditional value function in the above value function

$$E_t V_{t+1}(S_{t+1} \mid S_t, D_t) = \int V_{t+1}(S_{t+1}) * P_{t+1}(S_{t+1} \mid S_t, D_t) \tag{8}$$

where $P_{t+1}(S_{t+1} \mid S_t, D_t)$ represents the transition probabilities in the Social Security states. In addition, the above process is subject to uncertainties from health transition and wage earnings:

$$E_t V_{t+1}(S_{t+1} \mid S_t, D_t) = \sum_{h_t=0}^{2} k_t(h_t \mid h_{t-1}) \int_{y_t} f_t(y_t \mid aw_{t-1}) \int V_{t+1}(S_{t+1}) * P_{t+1}(S_{t+1} \mid S_t, D_t) dy_t \tag{9}$$

In the controlled stochastic process (9), wage income y_t follows a log-normal distribution given in equation (3). Health transition matrix is exogenous and estimated from data. Average wage aw_t follows the log-normal evolution given by equation (1), while the law of motion for wealth of period t+1 is:

$$w_{t+1} = R * (w_t + y_t + ssb_t(aw_t, y_t) * I_t(ss_t > 0) - c_t - \tau(y_t, w_t)) \tag{10}$$

where R is the return on savings and $I_t(ss_t > 0)$ is the indicator function for being on Social Security rolls.

The parameter values of preferences and beliefs used in solving the model are summarized in Table 1.1.

We solve the Markov stochastic decision problem expressed in (6) and (7) via numerical computation of the Bellman recursion for V_t since there is no analytical solution to it. The optimal decision rule can be stated as follows:

$$D_t^*(S_t) = \arg\max_{D_t} V_t(S_t) \tag{11}$$

To compute the condition expectation of the value function expressed in equation (9), we apply Gaussian quadrature to approximate the integral using summation following rules to choose quadrature abscissa and corresponding weights based on the properties of orthogonal polynomials corresponding to the density function of the variable over which we are integrating, in this case the draws of wage earnings following a log-normal distribution. The abscissa and weights are selected in such a way that finite-order polynomials can be integrated exactly using quadrature formulae.[13] At this point we are considering a one-dimensional problem, for which quadrature methods have been shown to be more accurate than Monte Carlo integration, low discrepancy sequences and weighted sums.

[13] For a detailed discussion of quadrature methods, refer to Rust (1996) and Judd (1998).

At each period the optimization in (11) is performed over the (w, aw) state space. We discretize wealth into 15 grid points and average wage into 8 grid points. So the total grid points of the (w, aw) state space is 120. Due to the discretization of continuous variables and the stochastic process, next period's

Table 1.1: Values of parameters of preferences and beliefs

Parameter	Description	Values
1-γ	CRRA	1.37
β	Discount Factor	0.96
k	Health transition matrix[a]: k_{11}: good to good; k_{12}: good to pd; k_{13}: good to fd; k_{21}: pd to good; k_{22}: pd to pd; k_{23}: pd to fd; k_{31}: fd to good; k_{32}: fd to pd; k_{33}: fd to fd.	k_{11}=0.95, k_{12}=0.04, k_{13}=0.01 k_{21}=0.25, k_{22}=0.68, k_{23}=0.07 k_{31}=0.05, k_{32}=0.10, k_{33}=0.85
$p_1(h)$	Award probability for fully disabled (h=2), partially disabled (h=1) and good health (h=0)	$p_1(h=2)$=0.62 $p_1(h=1)$=0.52 $p_1(h=0)$=0.42
$p_2(h)$	Audit probability for fully disabled, partially disabled and good health	$p_2(h=2)$=0.01 $p_2(h=1)$=0.02 $p_2(h=0)$=0.05

[a] "pd" stands for "partially disabled", and "fd" stands for "fully disabled".

value function's value will not always fall in the predefined grid points. Ideally we would solve for value function at all wealth and average wage levels. But it is computationally infeasible. Therefore we use two-dimensional simpicial interpolation algorithm[14] to find the value for the value function at the nearest grid point as an approximation of the true value.

Brent's routine to find a zero of a function uses the code from Numerical Recipes in C and modifies it to track the zero of derivative of the value function and compute the optimal decisions of consumption, labor supply and Social Security decisions for all the (w, aw) grid points, and all 10 Social Security states and the 3 health states and the 80 periods. The procedure is repeated until the solution of the first period problem is obtained.

1.3.2 Model of a Partial DI System

Under a partial DI system, we assume that an individual has options to apply for 100-percent, 75-percent, 50-percent, or 25-percent of full disability benefits. 100-percent benefits, or full benefits, are equivalent to those under the current DI system. The benefits amounts of the other three options are proportional to the full benefits amount. Every option is combined with a specific earnings limit, i.e. SGA level, so four SGA levels in this system correspond to four levels of DI

[14] Given in Algorithm 6.5 (p. 243) of Judd, 1998, Numerical methods in Economics (MIT Press).

benefit options. The partial benefits are designed to supplement a reduced (part-time) working income of those who have lost some work capacity but are still attached to labor force exerting residual work ability. If an individual receives a full benefit, she is allowed to earn up to $900 per month (i.e. $10,800 per year, we use annual based earnings in our model). The SGA levels for 75-percent, 50-percent, and 25-percent DI benefits are $21,600 per year, $32,400 per year, and $37,800 per year, respectively. We set those amounts in proportion to the SGA level for 100-percent DI benefits. [15] If the earned income exceeds the corresponding SGA limit, higher benefits will be reduced to lower benefit. For example, if a 100-percent DI beneficiary makes more than $10,800 in a year but still less than $21,600, she'll be moved down to the 75-percent DI roll. For 25-percent beneficiaries, benefits will be terminated in the case that they earn an annual earning higher than $37,800. The values of parameters of incentives under the baseline model and a partial disability system are summarized in Table 1.2 and Table 1.3, respectively.

Partial DI system encourages working and leaving the roll by moving higher benefits recipients to lower benefits levels instead of terminating them from the roll completely when they work more than the limit for the higher benefits. In that sense, it acts as a similar as the Trial Work Period (TWP) in

[15] For 100-percent DI benefits, SGA1=$10,800/year; for 75-percent DI benefits, SGA2=SGA1*2=$21,600/year; for 50-percent DI benefits, SGA3=SGA1*3=$32,400/year; for 25-percent DI benefits, SGA4=SGA1*3.5=$37,800/year.

current DI system, but is expected to be more effective fostering a *continuous* attachment to the labor force among the disabled, compared to the very limited time provided in TWP.

There are three more Social Security states under the partial system. ss_t takes three more values: ss_t =10, 11, 12, denoting being on 75-percent DI, 50-percent DI, and 25-percent DI, respectively. The dynamic decision problem of applying for Social Security benefits is illustrated in Figures 1.2-1 and 1.2-2.

Table 1.2: Values of parameters of incentives under baseline model

Parameters	Values
Substantial Gainful Activity level (SGA)	$10,800/year
Waiting period	One year
Earning test for retirees b/w ERA and NRA	$12,960/year
Earning tax rate for retirees b/w ERA and NRA	0.5
Earning test for retirees in year reaching NRA	$34,440/year
Earning tax rate for retirees in year reaching NRA	0.33
Maximum taxable Social Security earnings	$97,500/year
Social Security tax rate	0.15
Early Retirement Age (ERA)	62
Normal Retirement Age (NRA)	66
Maximum Retirement Age (MRA)	70
Actuarial reduction on early retirement benefits	on a sliding scale
Delayed retirement credit	0.03-0.08

Table 1.3: Values of parameters of incentives under a partial DI model

Parameters	Values (high SGA)	Values (low SGA)
SGA level for full DI benefits	$10,800/year	$10,800/year
SGA level for 75-percent DI benefits	$21,600/year	$13,500/year
SGA level for 50-percent DI benefits	$32,400/year	$16,200/year
SGA level for 25-percent DI benefits	$37,800/year	$18,900/year
Minimum earning requirement	Positive earnings	Positive earnings
Waiting period for all levels of benefits	One year	One year
Move downward	Approve immediately	Approve immediately
Move upward	Wait	Wait

1.4 Data and Calibration

Data used to calibrate the model are from a number of sources, including the Health and Retirement Study (HRS), Annual Statistical Report on DI program produced by the SSA, statistics on employment and population published by U.S. Census Bureau, and U.S. Life Table produced by U.S. Centers for Disease Control.

The HRS is a longitudinal study that follows persons aged 51-61 in 1992 and their households The HRS provides information on respondents' demographics, labor force participation, employment, and health status, Social Security and other program benefits, income, and wealth. The restricted data on earning histories of HRS cohorts are used to estimate the AIME, the base to calculate the Primary Insurance Amount (PIA) that Social Security beneficiaries receive. Wealth and wage levels of HRS cohorts are lower than the population average. So in calibration we see that the benefits of older beneficiaries are lower than average benefits of population.

The model is calibrated to the data for males. This way, we avoid modeling the fertility choice and the special labor force participation pattern among females.

The five-point-scale self-reported health status question and the work limitation question are used to define the health status in the model: 1) “Would you say your health is excellent, very good, good, fair, or poor?”; 2) “Do you have any impairment or health problem that limits the kind or amount of paid work you can do?”; 3) “Does this limitation keep you from working altogether?” Individuals who say they are in excellent, very good or good health are defined as being in *good* health. We define as the *partially disabled* those who say their health are fair or poor and they have work limitations (yes to question 2) but their work limitations do not keep them from work completely (no to question 3). The *fully disabled* in the mode are those in the data who report fair or poor health and have work limitations that keep them from work completely (yes to question 3). The health transition matrix is estimated from the HRS data. We are using health transition probability estimated from the HRS for all ages, which over estimate the proportion of the disabled among younger people than HRS sample, due to the fact that younger people have lower probabilities to develop disabilities compared to the elder. However, due to data limitation, we cannot find precise estimates of disability transition probability among younger people. We are aware that this limitation will over predict the DI application and awards among the young.

Mortality risk in the model is exogenously determined and estimated from the HRS data and comparable to the death rate in the United States Life Table[16].

The discount factor we use, β, is assumed to be 0.98, and the constant relative risk aversion parameter γ is 2.70. The utility function parameter, bequest function parameters, DI award probability, and DI audit probability were chosen to match the observed age profile of DI entitlement, DI rolls, average monthly DI benefits, and employment.

The model solution was used to simulate life cycle path for 5,000 artificial agents. Each agent starts at age 21 with given values of wealth (mean value is $26,200, minimum is $13,679, maximum is $67,172) and AIME (mean value is $20,100, minimum is $3,000, maximum is $48,989), calibrated to the values in the data. An initial health status is randomly assigned to the artificial agents to match the proportions in the data at the initial age. We assume that wage, mortality, health status, DI award probability and audit probability are randomly drawn from a uniform distribution. Then starting from period 1 (t=1), they make optimal choices about consumption, leisure, and Social Security applications. The choices they make this period will determine the state they will be next period, assuming all the uncertainties faced this period will realize at the beginning of next period. The uncertainties are from mortality, health transition, wage earnings,

[16] Death rates are taken from the U.S. Life Table for males 2003, *National Vital Statistics Report*, vol. 54, no. 14, 2006, produced by U.S. Center for Disease Control.

DI award probability and audit probability. This stochastic process repeats until the agent dies at the last period (age 100).

Figure 1.3-1.7 illustrate the fit of the model to the age profile of key variables. Figure 1.3 compares the simulated age profile of percentage of DI beneficiaries with the actual profile. We see that the model fits the age distribution of DI rolls well, although there is a less than 3 percent overestimation for age group 45-49 and 50-54 and less than 4 percent underestimation for those aged 60-64. Figure 1.3 shows the *stock* of the DI beneficiaries, the proportion of survivors receiving DI benefits, at each age group, while in Figure 1.4, we see the age distribution of the *flow* of DI recipients, that is, the age distribution of all the new awardees at each age group. The flow of DI rolls illustrated in Figure 1.4 shows an overestimation among those aged 40-44 and those aged 45-49, and an underestimation among those older than age 50-54, which represents a similar pattern as shown in Figure 1.3, except that the over-estimation appears a bit earlier in the *flow* (Figure 1.4) than in the *stock* (Figure 1.3). We can understand that time difference as a lagged reflection of the *flow* in the *stock*. As seen in Figure 1.3 and Figure 1.4, although discrepancies between simulation and reality exist, the model seems to have captured the general pattern of DI entitlement.

The above difference between the simulated and the actual age profile of DI beneficiaries is very likely due to the fact that younger people have lower probabilities to develop disabilities than elder people. However, in the model, due to data limitation, the disability transition probabilities we use are not age specific. The disability transition probabilities, which are embedded in health transition matrix, are estimated from the HRS data, a relatively older sample of whole population. Those probabilities also apply to the younger individuals in the model. Since in the model the DI award probability is a function increasing in health status (higher values of health status means worse health), and the audit probability is a function decreasing in health status, we are likely to have overestimated the award probability and underestimated the audit probability for the younger individuals. Therefore it is no surprise to see overestimation of percentage of DI recipients among the young.[17]

In Figure 1.5 and Figure 1.6, the model reproduces the age profile of average monthly DI benefits. The average monthly benefits are function of AIME which is a summary of one's earnings history. The model predicts the age profile of average monthly DI benefits quite well, implying that the underlying age profile of earnings histories must have been predicted well. Figure 1.5 shows the benefits of the *stock* of DI beneficiaries, while Figure 1.4 shows the benefits of the *flow* of DI entitlements. Both of figures have captured the general pattern of

[17] I have tried the simulation with some artificial age-specific disability transition probabilities (smaller probabilities for the young and bigger probabilities for the elder) and the results do seem to better match the actual age profile of DI entitlement. Due to space limitation, the results are not reported here.

increasing monthly benefits with age although there are some discrepancies in the slope of age-benefits relationship.

Those discrepancies are mostly due to the way we estimate the annual earnings and the way we approximate the average wage (aw) or AIME. We estimate one's annual earnings using the observed sequence of average wages calculated from the earning histories of HRS cohorts taken from the SSA restricted data. However, HRS cohorts have generally lower earning levels than current whole population. Therefore the annual earnings estimated from HRS cohorts' earning histories are likely to be lower than that of actual population. Figure 1.7 illustrates the age profile of median monthly wages for full-time workers. The simulated population has a generally lower wage level than the actual population. The wages levels for those aged at 55-64 are under predicted by about 2,200 dollars. This may explain part of the reason that the simulated average monthly DI benefits are underestimated for the older recipients.

Figure 1.8 shows that the general employment pattern predicted by the model matches the reality although the simulated employment rate is higher than the actual rate. The total employment rate of the actual male population is 0.72, compared to the simulated total employment rate, 0.80.

1.5 Simulation Results

We use the calibrated version of the benchmark model to simulate the behavioral response and welfare impact of the Partial DI system. The model was re-solved and re-simulated under the Partial DI system.

Figure 1.9 illustrates the impact of Partial DI system on labor supply. There is an averagely less than 10 percent decrease in full-time employment between age 36 and age 66. The effect on part-time employment is significant. From age 36 to age 66, the rise in part-time working is remarkable. It is worth noticing that there is a peak at age 66, right after the normal retirement age (65) in the model. It is very likely to be related to the absence of an Earnings Test those above NRA. The total impact of the Partial DI system on employment is shown to increase the labor supply focusing on age 40-60.

Figure 1.10 shows the one of the major effects of the Partial DI system, the induced entry effect. We find a considerable increase in total DI application under the Partial DI system. Specifically, there is a uniform decline in application of full DI benefits among individuals in their late thirties to early fifties. The changes in full benefits applications among those aged fifties are mixed. For those aged between 60 and before NRA, there are relatively high increases in applications for 100-percent DI benefits. According to our simulation, the DI applications will double the status quo level. However, in contrast to the increase in total applications, there is a significant decrease of 36.8 percent in full (100-percent) benefits applications. So the increase in DI applications under the Partial DI system is mainly due to applications for partial DI benefits. Among these partial DI benefits applicants, some are those who would have applied for full benefits under status quo (probably those in their late thirties to early fifties), and some are new applicants who would not have applied under status quo and now are induced to apply for partial benefits when partial options are available under Partial DI system (probably those aged between 60 and NRA). It implies that when available, the option to combine partial DI benefits and reduced work earnings is attractive to individuals who have work limitations but still have residual work capacities. From our simulation, the partial DI benefits options are especially attracted to the working-aged population (late thirties to early fifties).

Figure 1.11 shows the impact of the Partial DI system on DI rolls. In our simulation, the DI rolls will increase more than double the rolls under status quo, keeping the average award probability the same as in status quo. However, the 100-percent DI roll decline considerably by 24.2 percent compared to the DI roll under status quo. So the increase in DI rolls under the Partial DI system is mostly due to the increase of those recipients receiving partial DI benefits.

Figure 1.12 shows the impact of Partial DI system on the distribution of ages of first entitlement to DI benefits. The mean age of first entitlement to DI is

47.1 under status quo. In our simulation of Partial DI system, the mean age of first entitlement to 100-percent DI benefits is 51.7, and the mean age of first entitlement to partial DI benefits is 49. Compared to the status quo, the mean age of first entitlement to DI benefits has been postponed by 2 to 4 years under the Partial DI system.

Figure 1.13 shows the impact of Partial DI system on Social Security benefits and contributions. The left panel in the figure shows that there is a uniform remarkable drop in the mean Social Security benefits of recipients aged below 62 (the Early Retirement Age) who are made up of only DI beneficiaries, while there is hardly any effect on the Social Security benefits of those above age 62 who are mainly Social Security Old Age beneficiaries. The right panel in the figure shows a slight decline in Social Security contributions from those aged 38 to age 65. According to our calculation based on the simulated data, under the Partial DI system, the present value of Social Security benefits will decrease by almost 40 percent, and the present value of Social Security contribution will go down by 10.9 percent. Taking into account the 2.4 percent drop in present value of Federal income tax payments, the present value of cost of DI rolls will decrease significantly by more than half of the status quo level.

Figure 1.14 shows the impact of Partial DI system on consumption and wealth. The Partial DI system has very small effect on consumption profile and wealth accumulation only for those aged above mid-seventies.

Figure 1.15 illustrates the impact of Partial DI system on current period utility and expected discounted utility. There is a hardly noticeable effect on instantaneous utility. However, the impact on expected discounted utility (the continuous value) is remarkable. This positive impact gets smaller as the individual gets older.

I also simulate the effect of a partial DI system using a set of lower SGA levels to check the robustness or sensitivity of the results. These results are illustrated in the Figures 1.16-1.20. We see that the partial DI system with lower SGA levels (other parameters being the same as in the previous partial DI model I first simulate with) do not have significant effect on labor force participation, DI application and rolls, or government budget.

1.6 Conclusions and Policy Discussion

In the chapter we use a calibrated life-cycle model to predict behavioral responses after a partial benefits option is introduced into the current Social Security Disability Insurance program.

We find that substantial increases are predicted in DI applications and DI rolls when changing from status quo to a partial DI system. However, most of the increases are due to applications for *partial* benefits and awards to *partial* benefits. In fact, there will be a decrease of 36.8 percent in applications for *full* DI benefits, and a drop of 24.2 percent in *full* DI benefit rolls. The mean duration spent on DI will decrease from 14.4 years to 7.6 years. This may be due to the continuous attachment to the labor force under the partial DI system which makes DI recipients go back to labor force more easily and allows workers to apply for DI while still working. So we observe many short spells spent on DI. Our budgetary and welfare calculation shows that a partial DI system, under some conditions, could result in financial savings for the government as well as individuals' welfare improvement.

Of course, there are several degrees of freedom in the model that policy makers can play with to make a partial DI system reach the goal of efficiency and equity. First, it needs to be specified how many DI benefit levels exist in the partial system, and accordingly what should be the SGA levels for each benefits level that need to be set up according to the indexed wage levels in the nation. Second, it needs to be decided whether partial DI benefits recipients should enjoy any health insurance benefits, since it is well recognized that Medicare benefits provided by DI program create one of the most important incentives for the disabled to apply for DI. Considering that in most European countries with partial DI systems, universal health insurance is available, it is crucial to introduce the appropriate policy regarding health insurance benefits for those on partial DI benefit rolls, if a partial DI system is to be implemented. Third, in European countries with a partial DI system, there are employment services provided by the government to the disability benefits applicants before benefits award decisions are made. Full benefits are awarded if employment services cannot help partial benefits applicants find a job. Those countries take into account the labor market conditions while making disability benefit acceptance decisions. Whether we would do the same or not if a partial DI system is to be implemented in the US is left for policy makers and researchers to explore its possibility. The shortcomings of the model in this paper relate to the latter two aspects discussed above. One is that an important component of the DI program, Medicare, is not modeled. So we could not discuss the possibility of some health insurance benefits design accompanying the DI cash benefits. Once we include health insurance into the model, larger induced entry effect is likely to be expected. Another possible extension of the model in the paper is to include uncertainty of job offers or job availability and unemployment probability. Without those uncertainties, the model is likely to under-predict the partial DI benefits applications, especially considering there are minimum work requirements for partial DI benefits applicants in the model.

Table 1.4: Mortality rates by age and health status

Age	US Males	Disabled	Poor Health	Good Health
21	0.998608	0.9980512	0.9983296	0.9987472
22	0.998551	0.9979714	0.9982612	0.9986959
23	0.998544	0.9979616	0.9982528	0.9986896
24	0.998576	0.9980064	0.9982912	0.9987184
25	0.998624	0.9980736	0.9983488	0.9987616
26	0.998666	0.9981324	0.9983992	0.9987994
27	0.998692	0.9981688	0.9984304	0.9988228
28	0.998689	0.9981646	0.9984268	0.9988201
29	0.998661	0.9981254	0.9983932	0.9987949
30	0.998623	0.9980722	0.9983476	0.9987607
31	0.998583	0.9980162	0.9982996	0.9987247
32	0.998529	0.9979406	0.9982348	0.9986761
33	0.998459	0.9978426	0.9981508	0.9986131
34	0.998372	0.9977208	0.9980464	0.9985348
35	0.998271	0.9975794	0.9979252	0.9984439
36	0.998152	0.9974128	0.9977824	0.9983368
37	0.998005	0.997207	0.997606	0.9982045
38	0.997829	0.9969606	0.9973948	0.9980461
39	0.997635	0.996689	0.997162	0.9978715
40	0.997434	0.9964076	0.9969208	0.9976906
41	0.997225	0.996115	0.99667	0.9975025
42	0.996994	0.9957916	0.9963928	0.9972946
43	0.99673	0.995422	0.996076	0.997057
44	0.996434	0.9950076	0.9957208	0.9967906
45	0.996111	0.9945554	0.9953332	0.9964999
46	0.995775	0.994085	0.99493	0.9961975
47	0.995425	0.993595	0.99451	0.9958825
48	0.995068	0.9930952	0.9940816	0.9955612
49	0.994697	0.9925758	0.9936364	0.9952273
50	0.994292	0.9920088	0.9931504	0.9948628
51	0.993852	0.9913928	0.9926224	0.9944668
52	0.993394	0.9907516	0.9920728	0.9940546
53	0.992926	0.9900964	0.9915112	0.9936334
54	0.992439	0.9894146	0.9909268	0.9931951
55	0.991918	0.9886852	0.9903016	0.9927262
56	0.991338	0.9878732	0.9896056	0.9922042
57	0.990668	0.9869352	0.9888016	0.9916012
58	0.989872	0.9858208	0.9878464	0.9908848
59	0.988939	0.9845146	0.9867268	0.9900451
60	0.987843	0.9829802	0.9854116	0.9890587
61	0.986621	0.9812694	0.9839452	0.9879589

Table 1.4: Mortality rates by age and health status (Continued)

Age	US Males	Disabled	Poor Health	Good Health
62	0.985342	0.9794788	0.9824104	0.9868078
63	0.984078	0.9777092	0.9808936	0.9856702
64	0.982814	0.9759396	0.9793768	0.9845326
65	0.981462	0.9740468	0.9777544	0.9833158
66	0.979911	0.9718754	0.9758932	0.9819199
67	0.978153	0.9694142	0.9737836	0.9803377
68	0.976155	0.966617	0.971386	0.9785395
69	0.973947	0.9635258	0.9687364	0.9765523
70	0.971685	0.960359	0.966022	0.9745165
71	0.969307	0.9570298	0.9631684	0.9723763
72	0.96656	0.953184	0.959872	0.969904
73	0.963307	0.9486298	0.9559684	0.9669763
74	0.959601	0.9434414	0.9515212	0.9636409
75	0.955706	0.9379884	0.9468472	0.9601354
76	0.951726	0.9324164	0.9420712	0.9565534
77	0.947397	0.9263558	0.9368764	0.9526573
78	0.942549	0.9195686	0.9310588	0.9482941
79	0.937091	0.9119274	0.9245092	0.9433819
80	0.930929	0.9033006	0.9171148	0.9378361
81	0.924241	0.8939374	0.9090892	0.9318169
82	0.917158	0.8840212	0.9005896	0.9254422
83	0.909777	0.8736878	0.8917324	0.9187993
84	0.901863	0.8626082	0.8822356	0.9116767
85	0.893006	0.8502084	0.8716072	0.9037054
86	0.883462	0.8368468	0.8601544	0.8951158
87	0.873198	0.8224772	0.8478376	0.8858782
88	0.862185	0.807059	0.834622	0.8759665
89	0.850393	0.7905502	0.8204716	0.8653537
90	0.837801	0.7729214	0.8053612	0.8540209
91	0.824387	0.7541418	0.7892644	0.8419483
92	0.81014	0.734196	0.772168	0.829126
93	0.795053	0.7130742	0.7540636	0.8155477
94	0.779126	0.6907764	0.7349512	0.8012134
95	0.762368	0.6673152	0.7148416	0.7861312
96	0.744799	0.6427186	0.6937588	0.7703191
97	0.726447	0.6170258	0.6717364	0.7538023
98	0.70735	0.59029	0.64882	0.736615
99	0.687557	0.5625798	0.6250684	0.7188013

Note: The second column in the table is taken from 2003 U.S. Life Table. The 3rd-5th columns are adjusted in an ad hoc way by health status and index the rates in second column off by the proportion of different health status in the whole population.

Figure 1.1-1: Decision tree for a dynamic Social Security application problem (age<ERA)

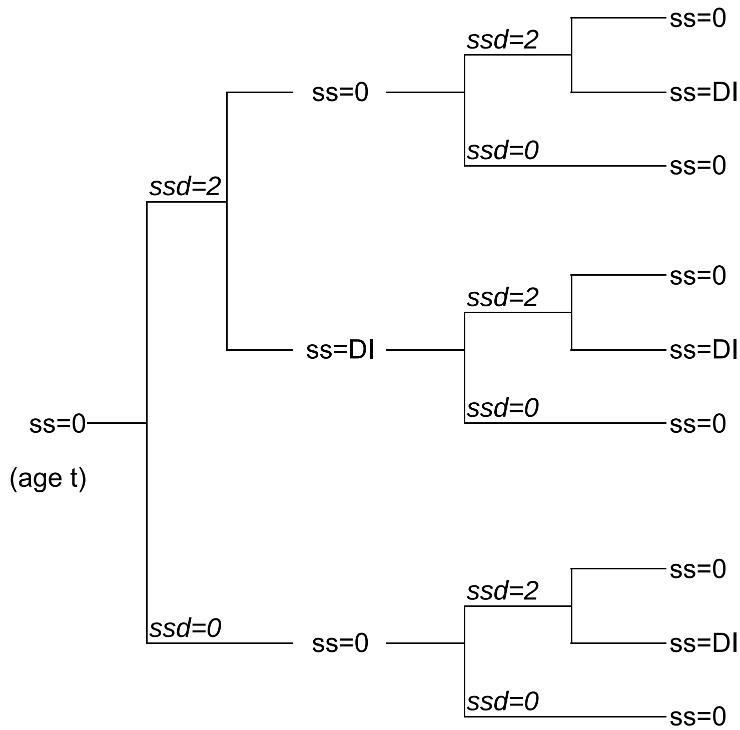


Figure 1.1-2: Decision tree for a dynamic Social Security application problem (ERA≤age<NRA)

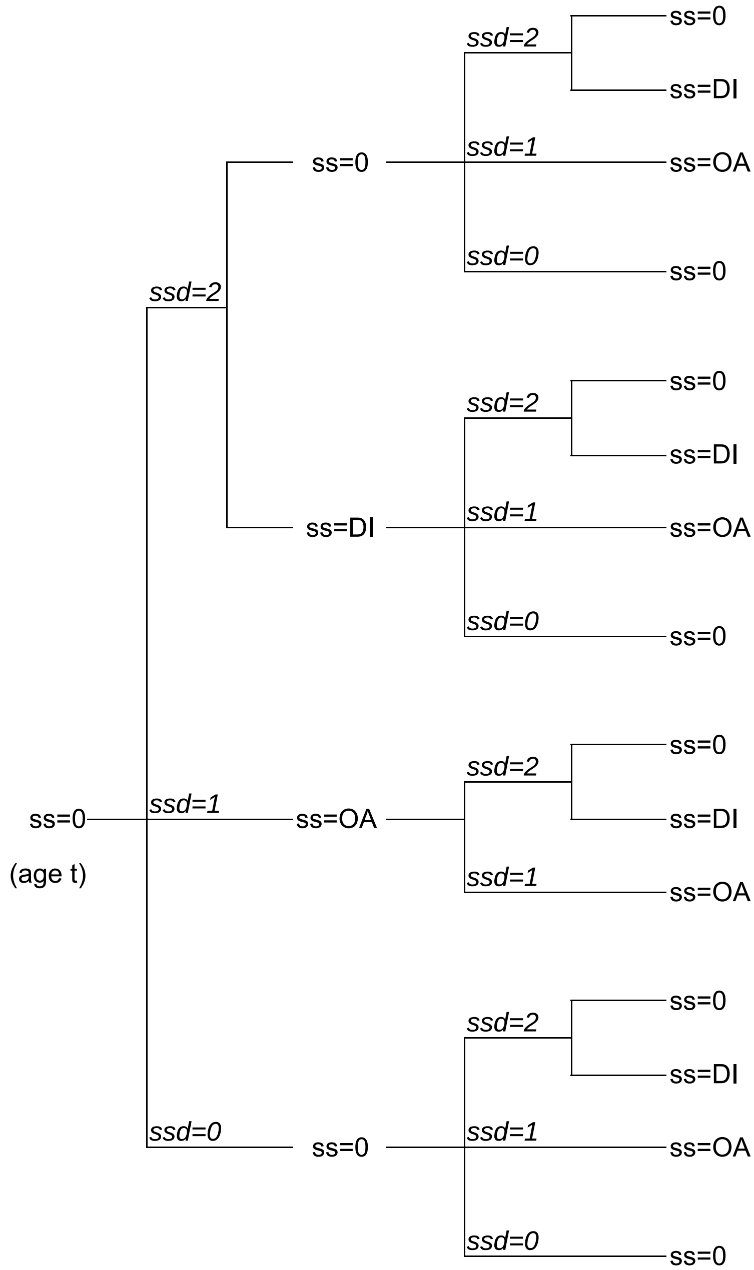


Figure 1.1-3: Decision tree for a dynamic Social Security application problem (NRA≤age<MRA)

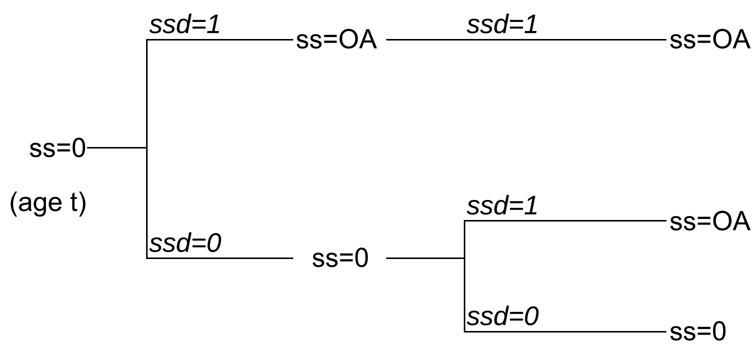
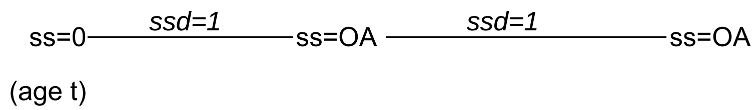


Figure 1.1-4: Decision tree for a dynamic Social Security application problem (age≥MRA)



Note: In the above figures, the values of Social Security choice, *ssd*, and Social Security state, *ss*, are as follows:

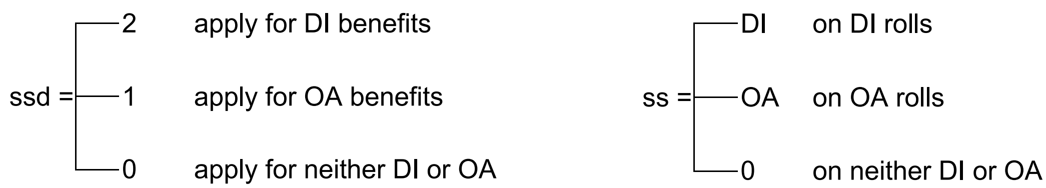
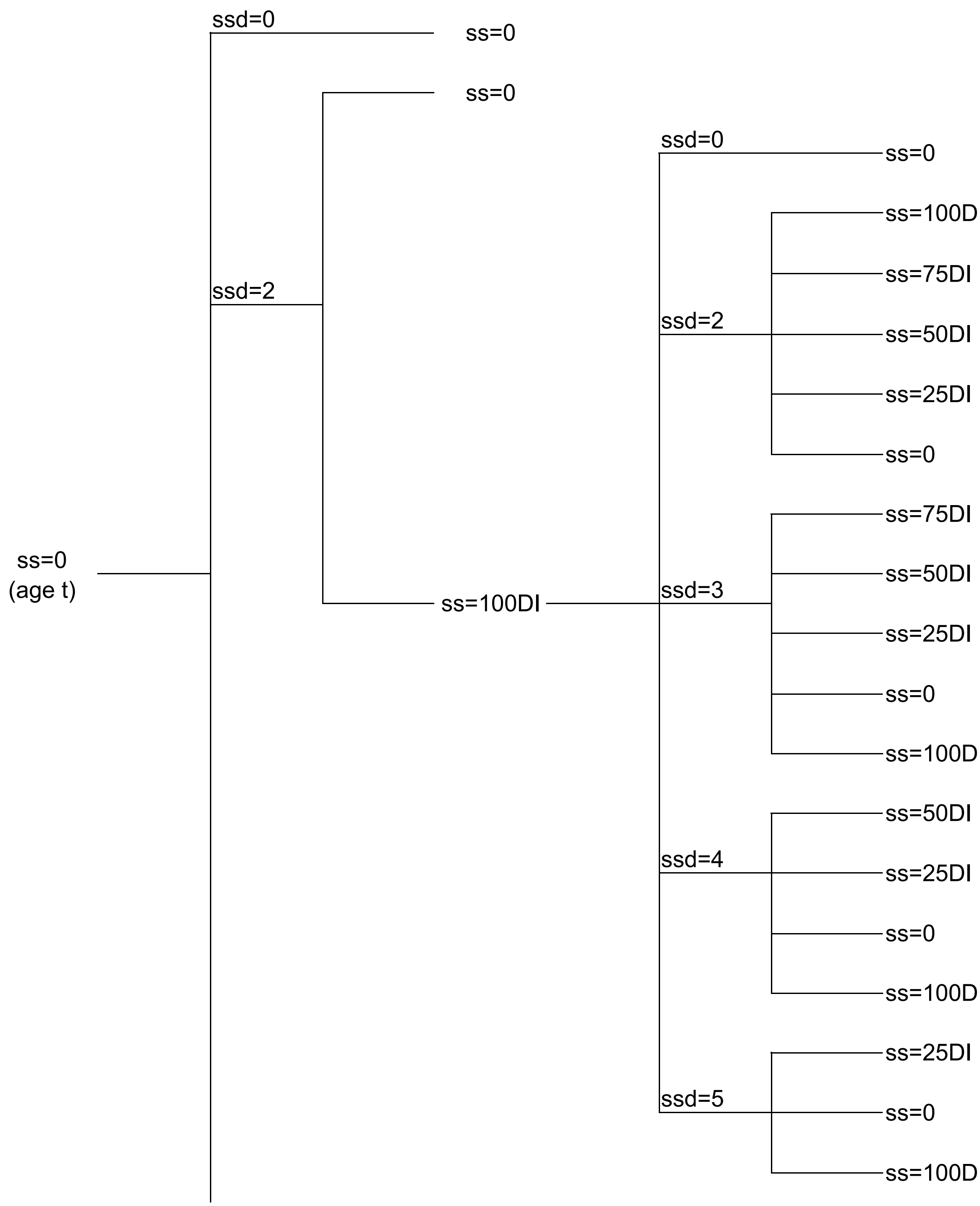
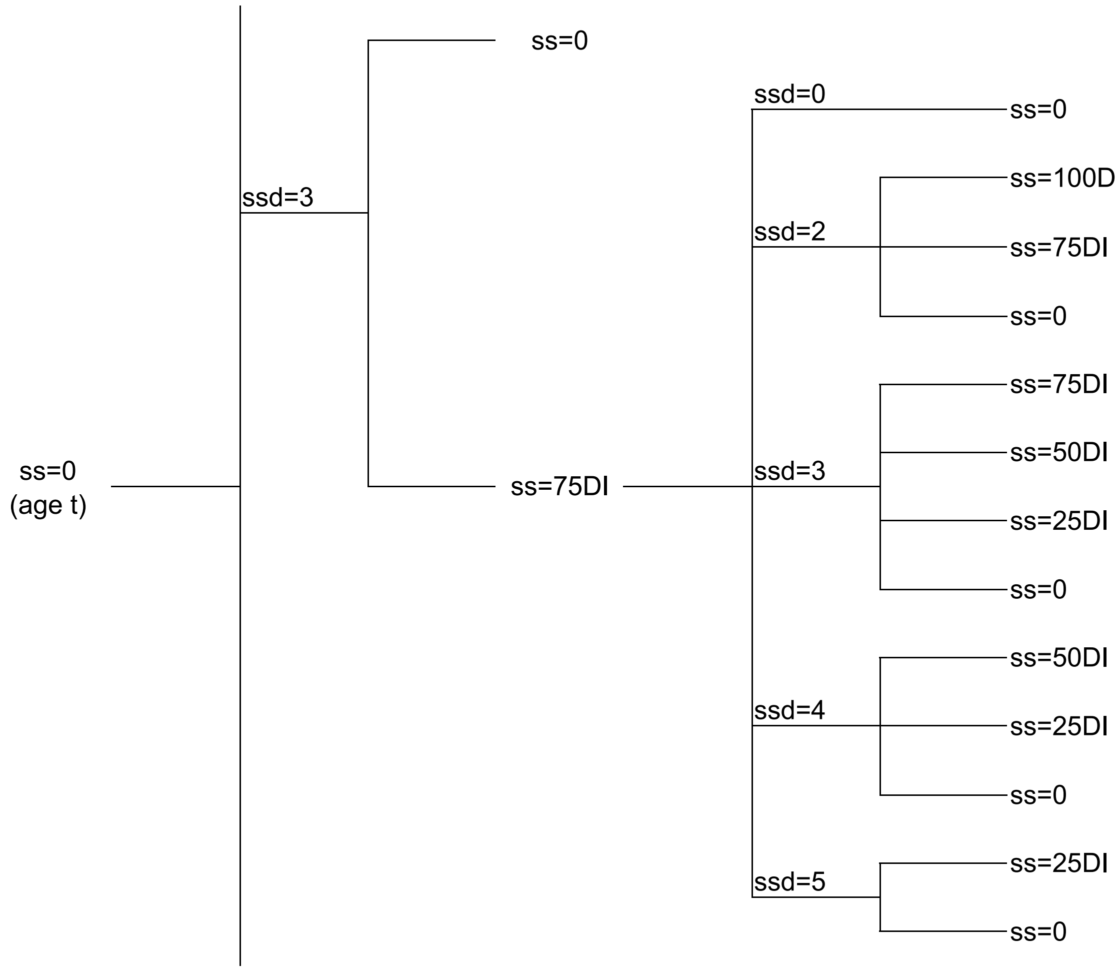
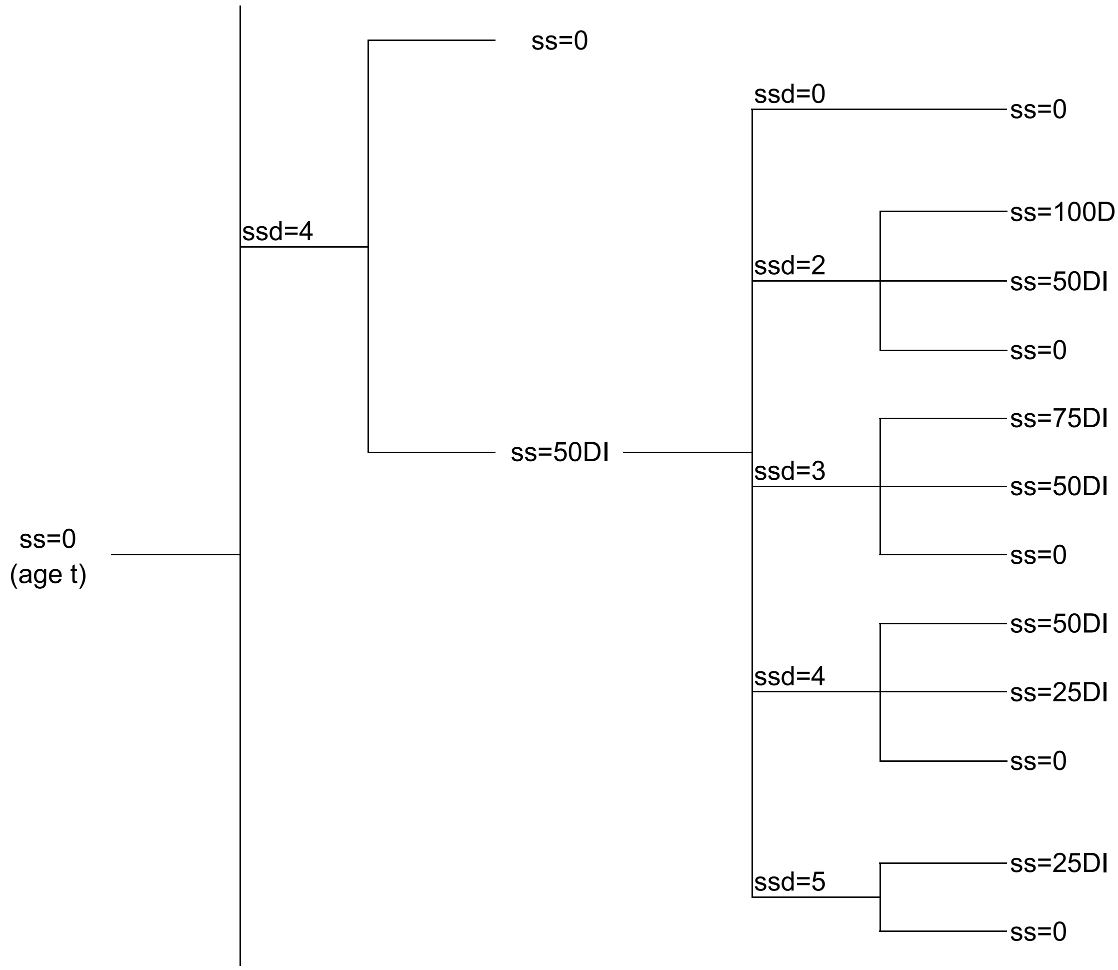


Figure 1.2-1: Decision tree for a dynamic Social Security application problem with Partial DI options (age<ERA)





ss=0
(age t)
ssd=3
ss=0
ss=75DI
ssd=0
ss=0
ssd=2
ss=100DI
ss=75DI
ss=0
ssd=3
ss=75DI
ss=50DI
ss=25DI
ss=0
ssd=4
ss=50DI
ss=25DI
ss=0
ssd=5
ss=25DI
ss=0


ss=0
(age t)
ssd=4
ss=0
ss=50DI
ssd=0
ss=0
ssd=2
ss=100DI
ss=50DI
ss=0
ssd=3
ss=75DI
ss=50DI
ss=0
ssd=4
ss=50DI
ss=25DI
ss=0
ssd=5
ss=25DI
ss=0

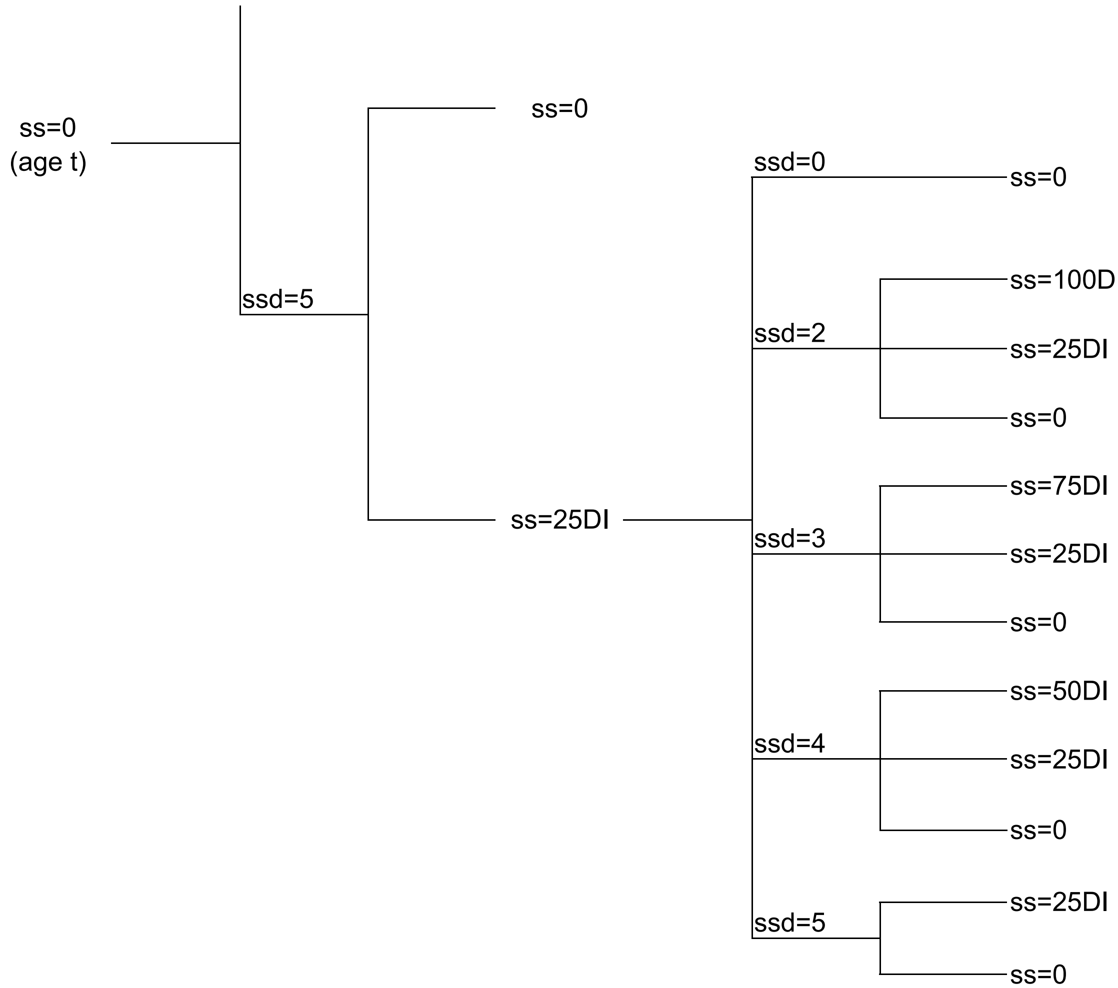
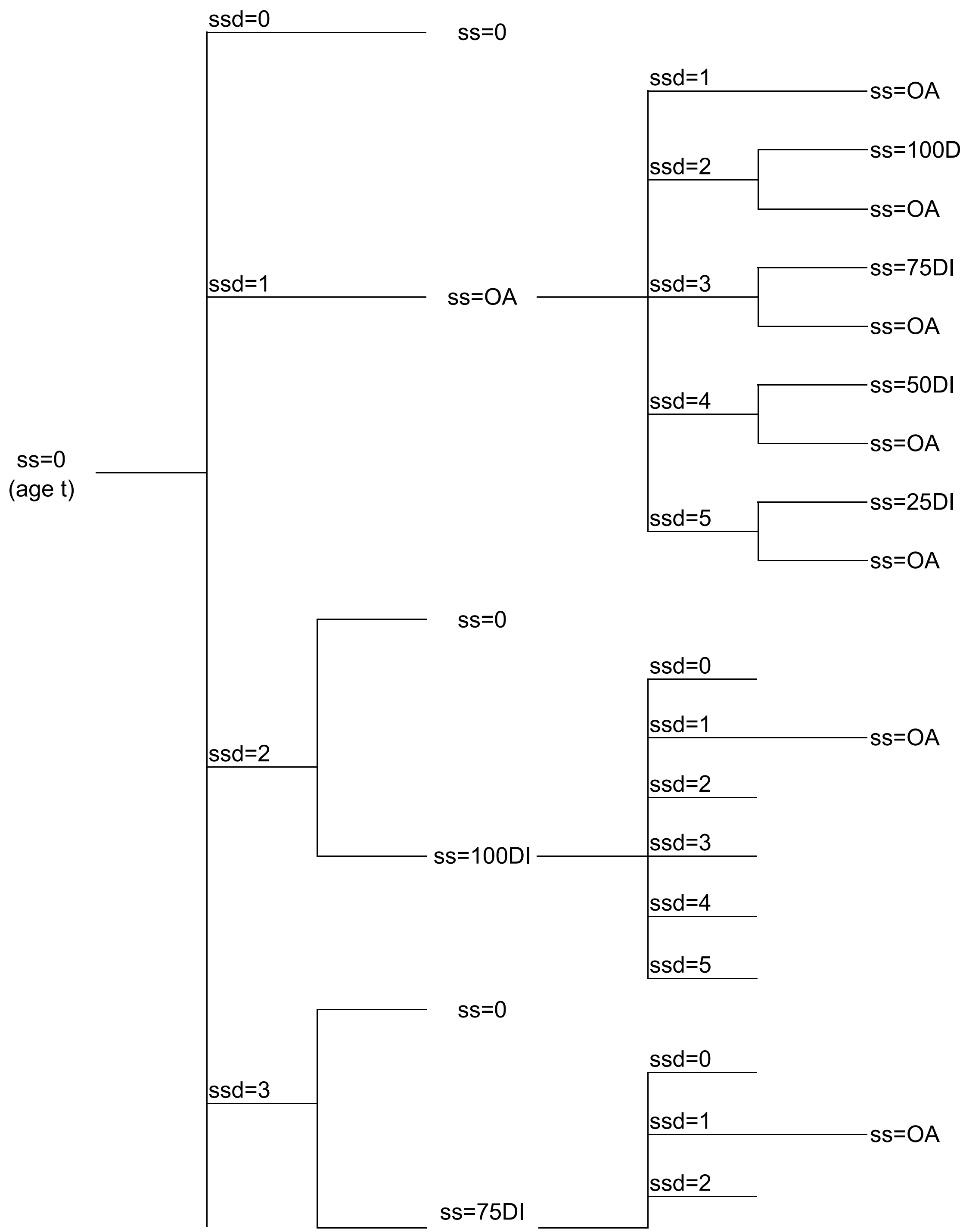
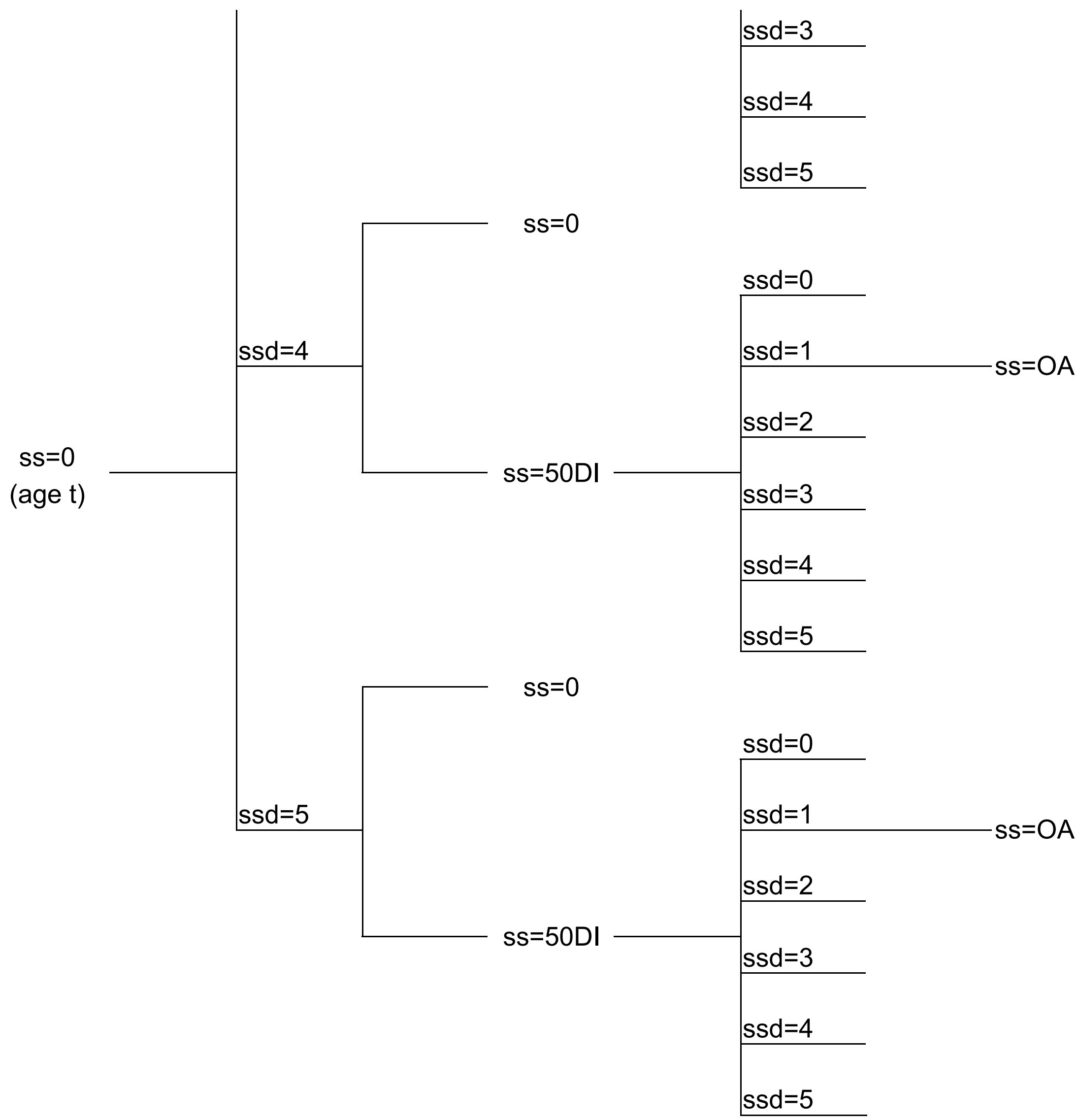

ss=0
(age t)
ssd=5
ss=0
ss=25DI
ssd=0
ss=0
ssd=2
ss=100DI
ss=25DI
ss=0
ssd=3
ss=75DI
ss=25DI
ss=0
ssd=4
ss=50DI
ss=25DI
ss=0
ssd=5
ss=25DI
ss=0

Figure 1.2-2: Decision tree for a dynamic Social Security application problem with Partial DI options (ERA≤age<NRA)





ssd=3
ssd=4
ssd=5
ss=0
ssd=0
ssd=4
ssd=1
ss=OA
ssd=2
ss=0
(age t)
ss=50DI
ssd=3
ssd=4
ssd=5
ss=0
ssd=0
ssd=5
ssd=1
ss=OA
ssd=2
ss=50DI
ssd=3
ssd=4
ssd=5

Note: In Figures 2-1 and 2-2, the values of Social Security choice, *ssd*, and Social Security state, *ss*, are as follows:

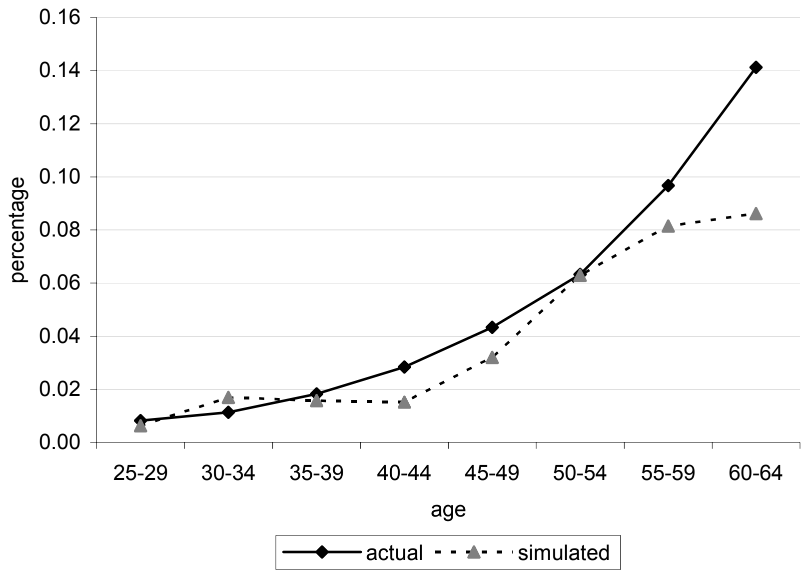
ssd =

0	apply for neither DI or OA
1	apply for OA benefits
2	apply for full DI benefits
3	apply for 75-perccent-DI benefits
4	apply for 50-percent-DI benefits
5	apply for 25-percent-DI benefits

ss =

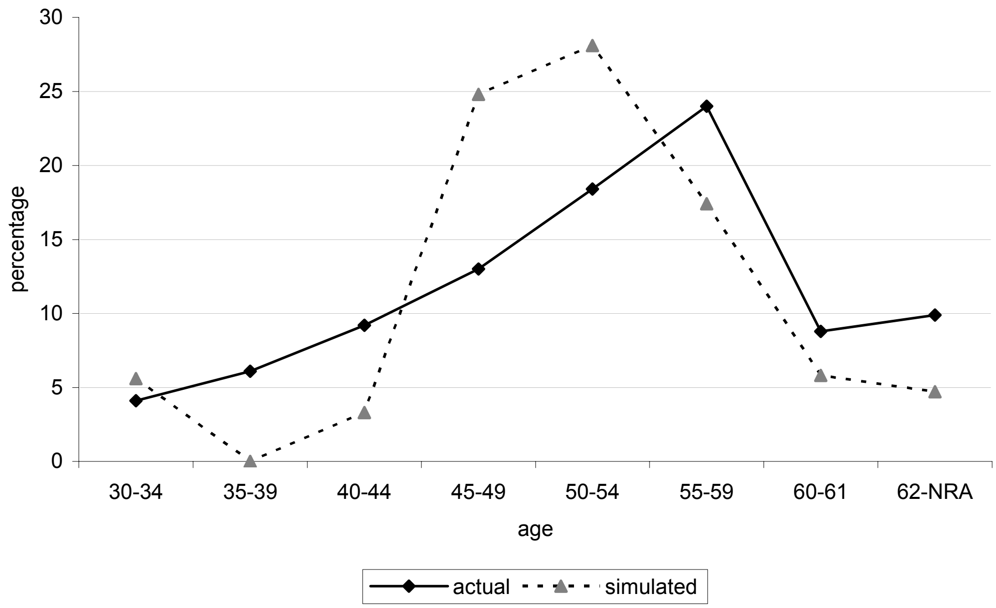
0	on neither DI or OA
OA	on OA rolls
100DI	on full DI roll
75DI	on 75-perccent-DI roll
50DI	on 50-perccent-DI roll
25DI	on 25-perccent-DI roll

Figure 1.3: Percentage of DI worker-beneficiaries by age



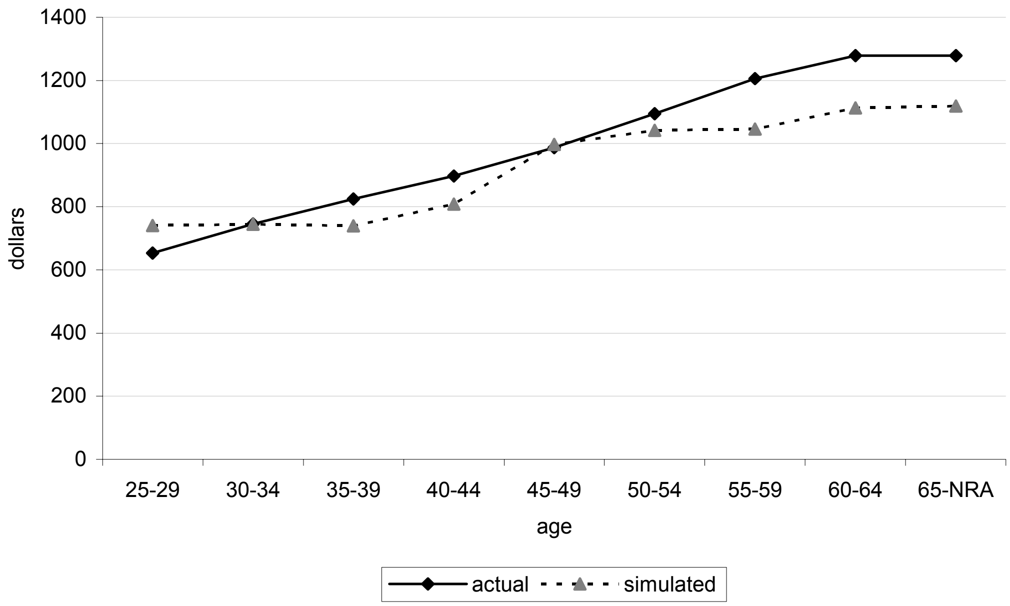
Note: The actual percentage is author's calculation based on population estimated produced by US Census Bureau and Table 4 of Annual Statistical Report on the DI program, 2006. We cannot calculate the actual award rate for age 65-66 since we don't have the statistics for population at that age range.

Figure 1.4: age distribution of DI awardees



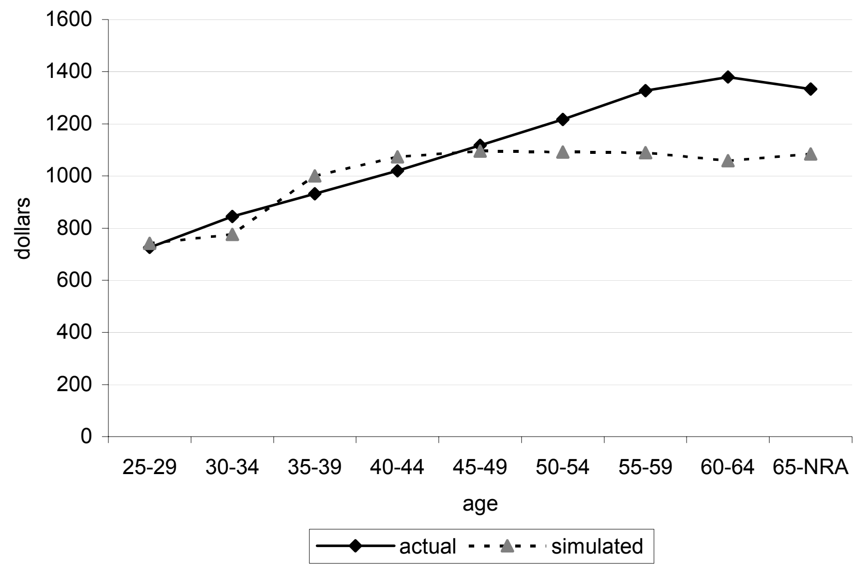
Note: The actual statistics are from Table 39 of *Annual Statistical Report on the DI program, 2006*. We include only disabled workers. Their dependents are not included in the calculation.

Figure 1.5: average monthly DI benefits by age

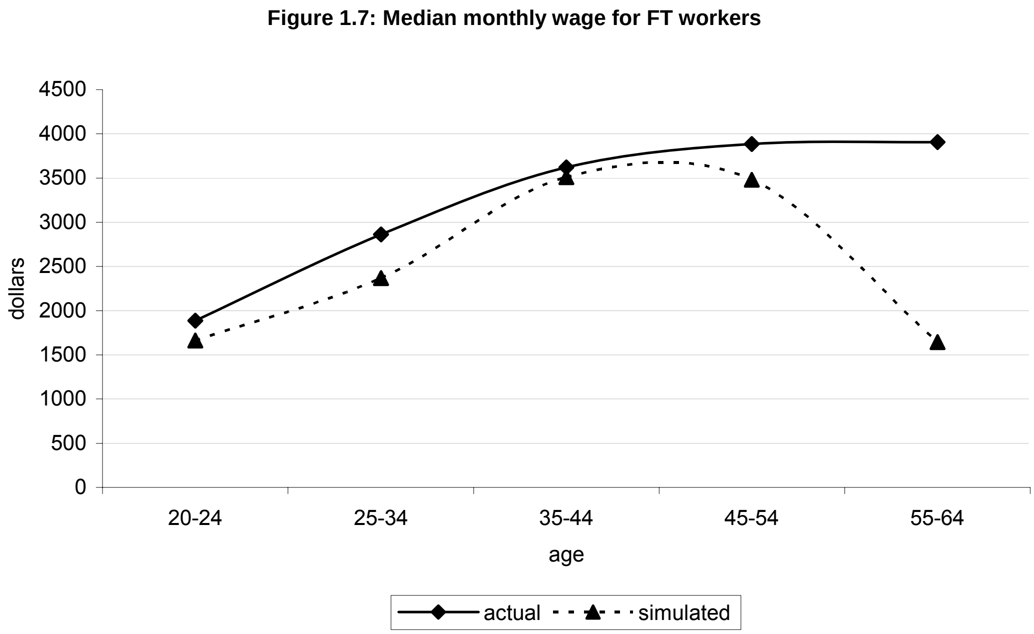


Note: The actual statistics are from Table 4 of Annual Statistical Report on the DI program, 2006. We include only disabled workers. Their dependents are not included in the calculation.

Figure 1.6: average montly DI benefits, by basis of entitlement of age

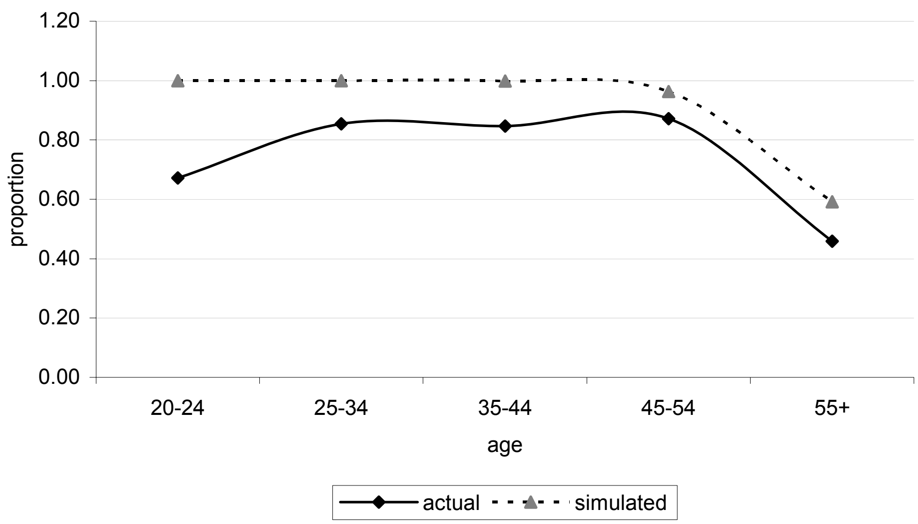


Note: The actual statistics are from Table 36 of Annual Statistical Report on the DI program, 2006. Benefits are in 2006 dollars. NRA=Normal Retirement Age.



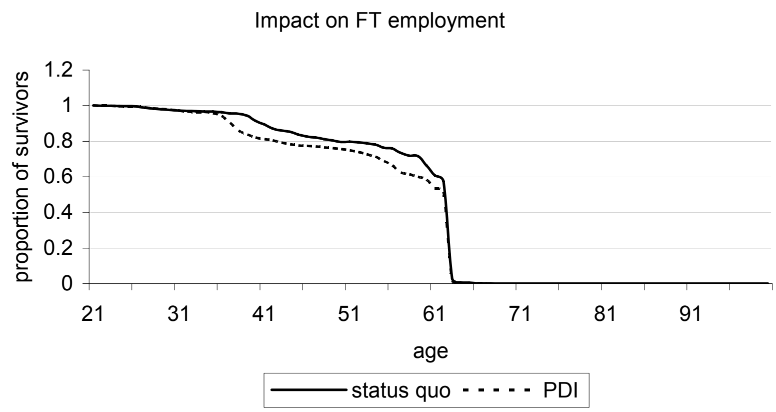
Source: The actual wage is author's calculation based on U.S. BLS Tables of the Usual Weekly Earnings of Wage and Salary Workers, 2006.

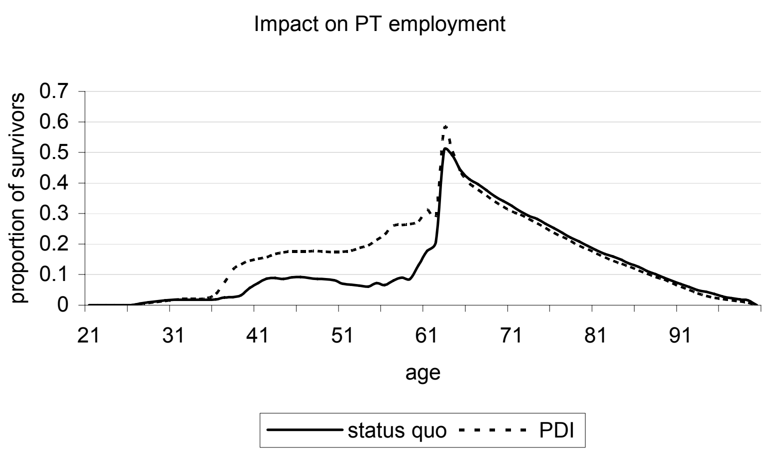
Figure 1.8: employment rate by age



Note: The actual employment rates are author's calculation based on BLS Employment Situation Summary Table A-6, 2007 and Population Division, U.S. Census Bureau Table 1: Annual Estimates of the Population by Sex and Five-Year Age Groups for the United States released in May 2006.

Figure 1.9: Impact on Employment





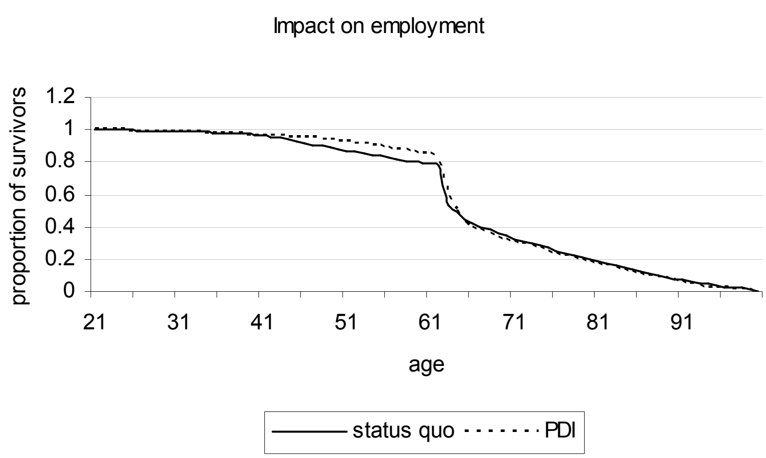
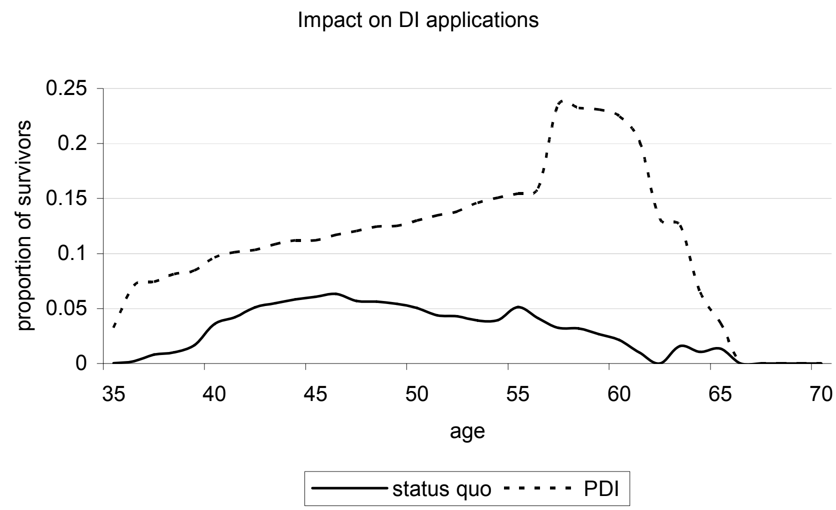


Figure 1.10: Impact on DI applications



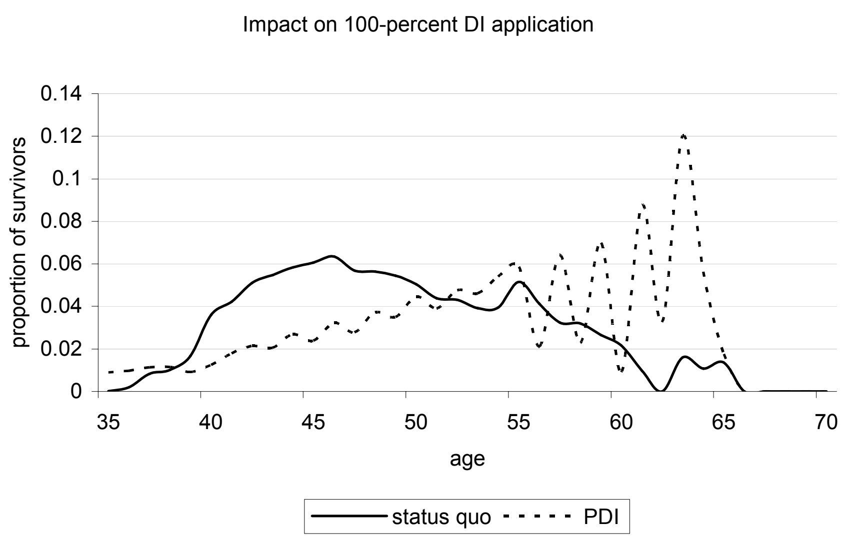
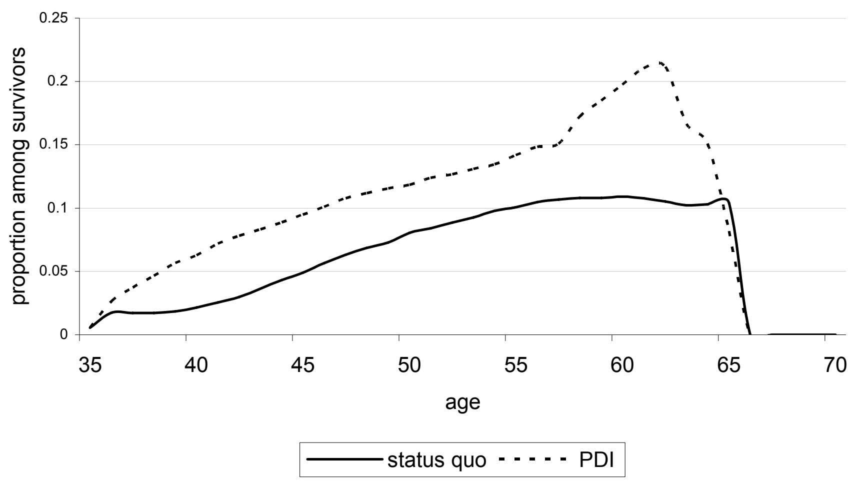


Figure 1.11: Impact on DI rolls

Impact on DI recipients



Impact on 100-percent DI roll

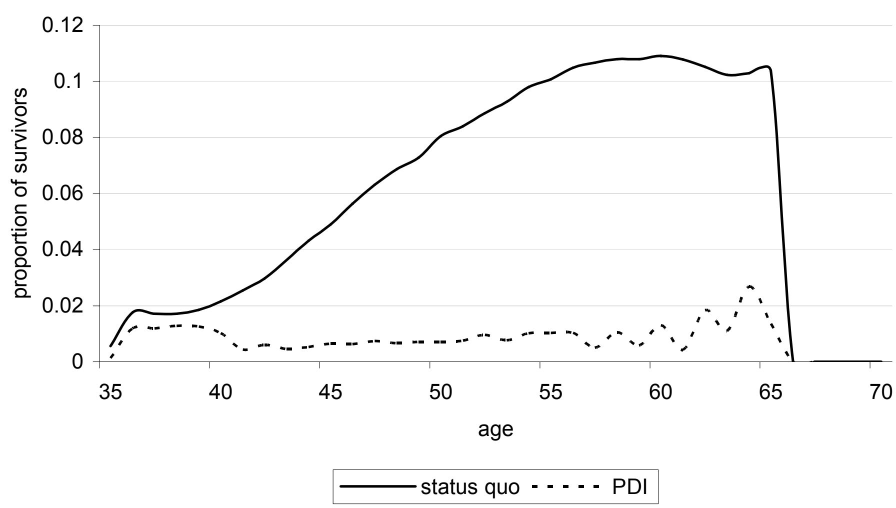
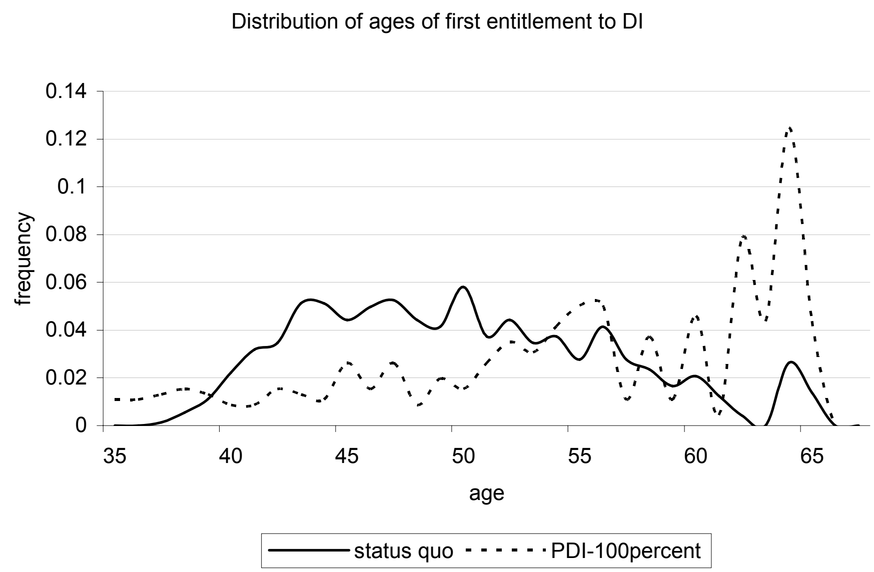


Figure 1.12: Distribution of ages of first entitlement and application to DI



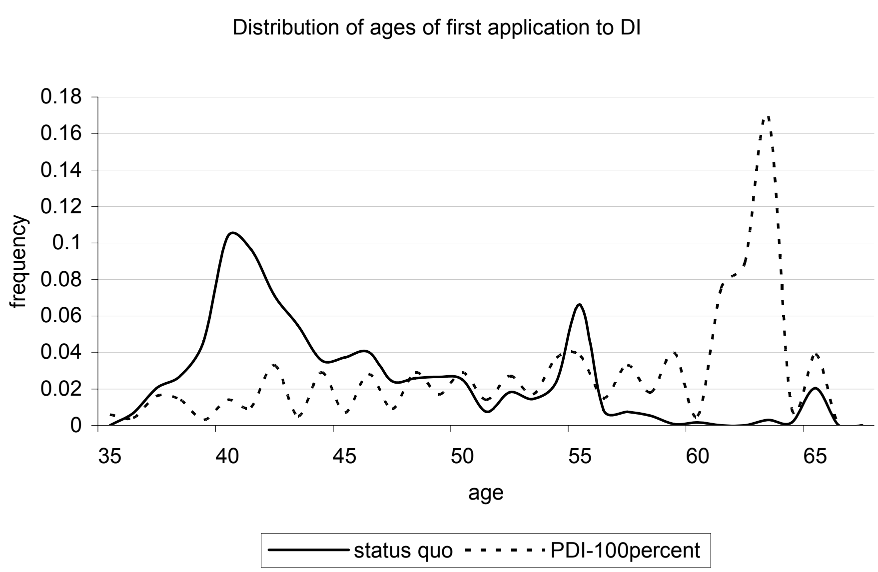
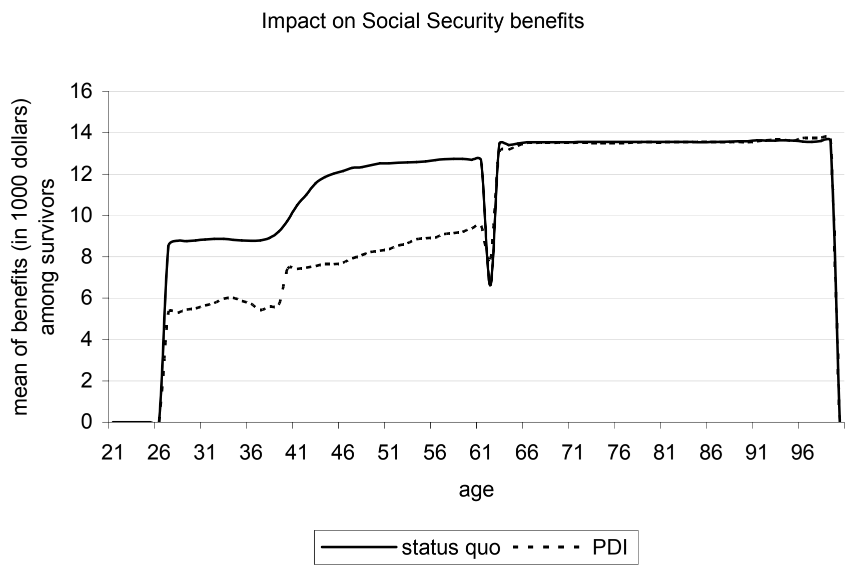


Figure 1.13: Impact on Social Security benefits and contributions



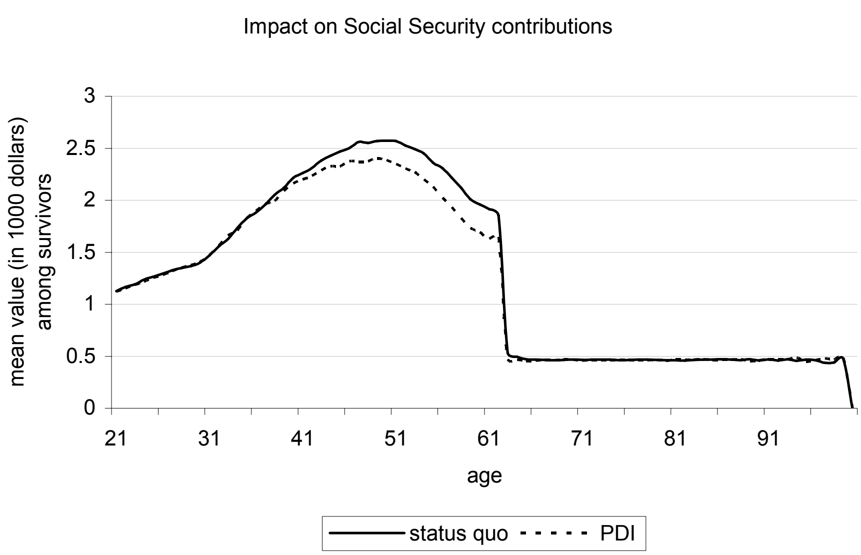
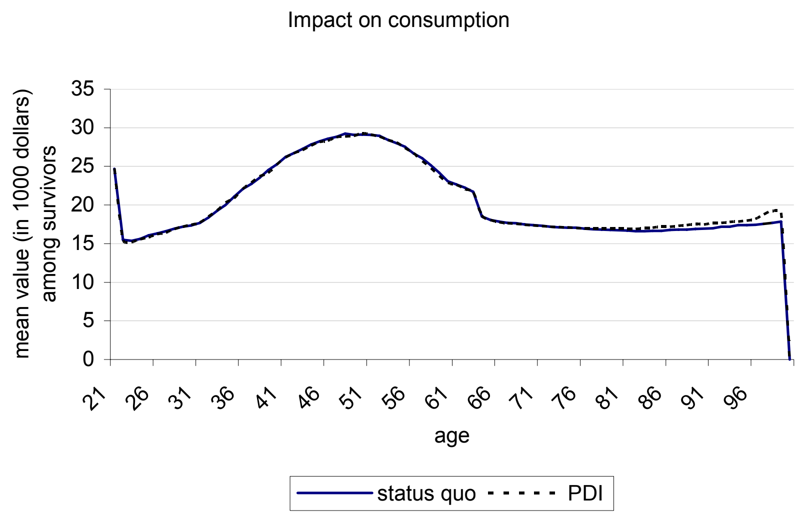


Figure 1.14: Impact on consumption and wealth



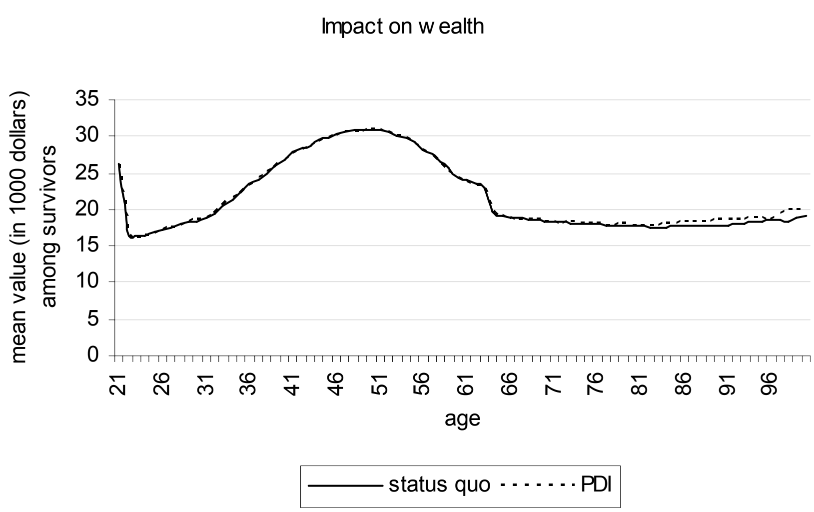
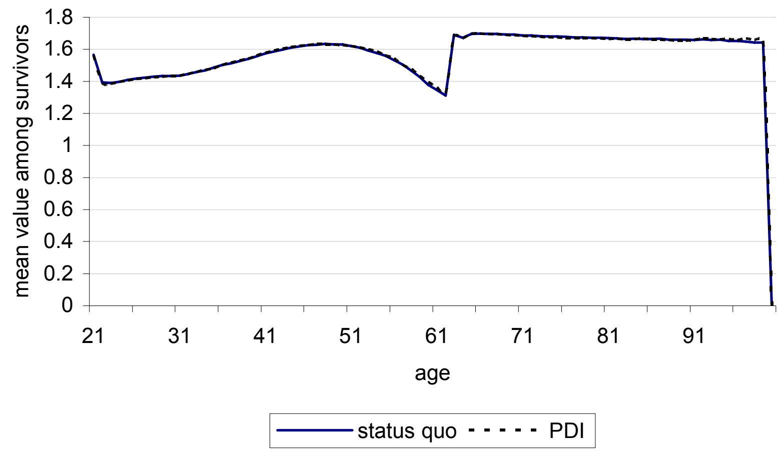


Figure 1.15: Impact on utility

Impact on current instantaneous utility



Impact on expected discounted utility

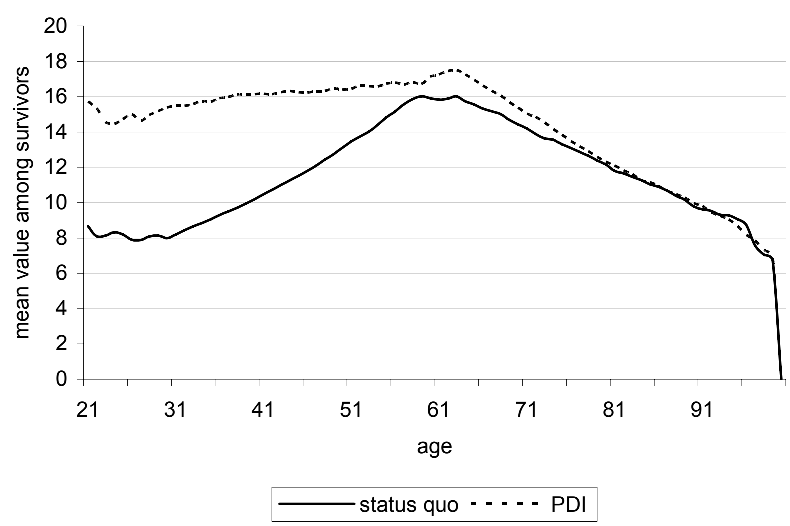


Figure 1.16: Impact on Employment (Low SGA)

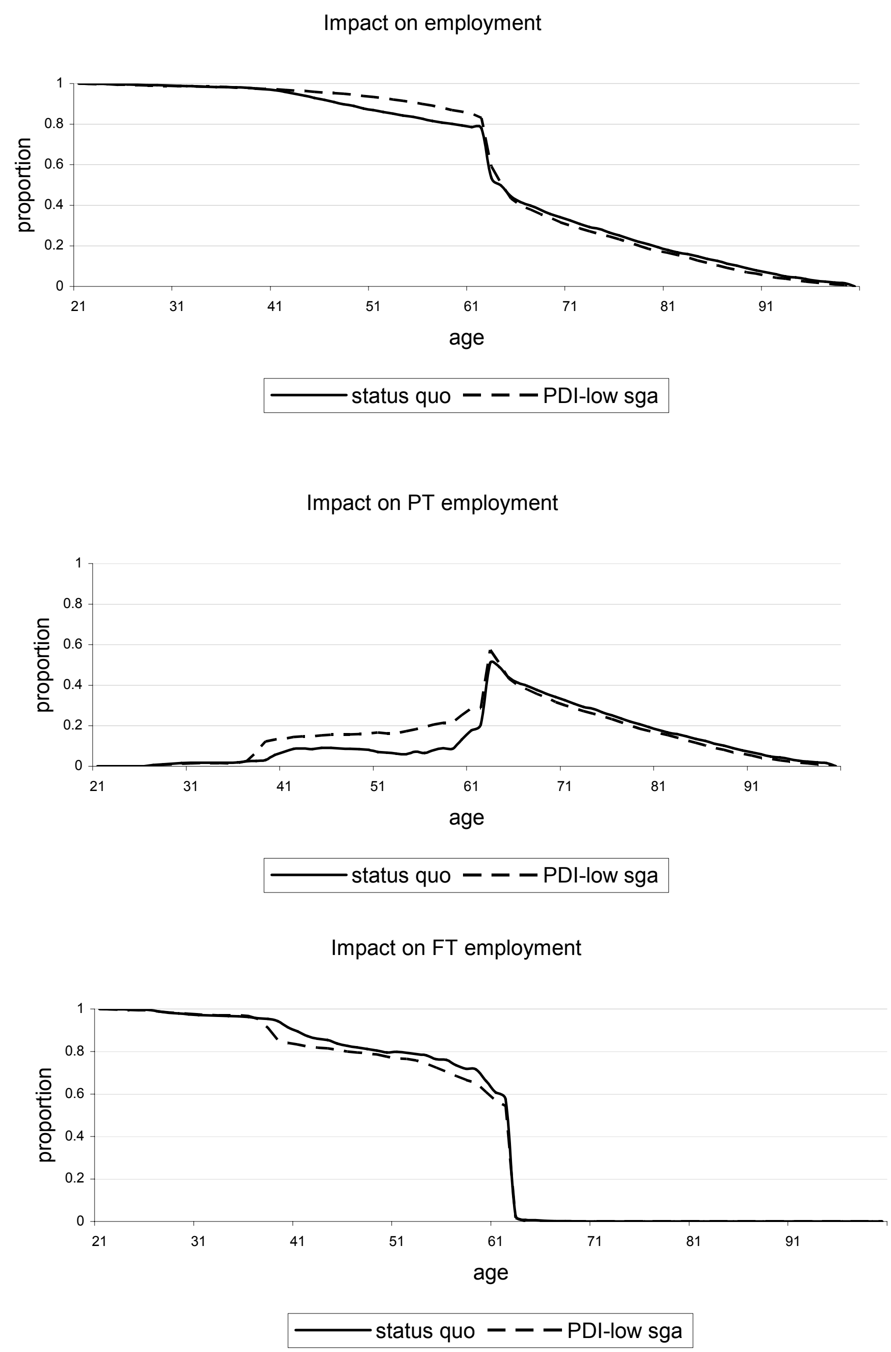
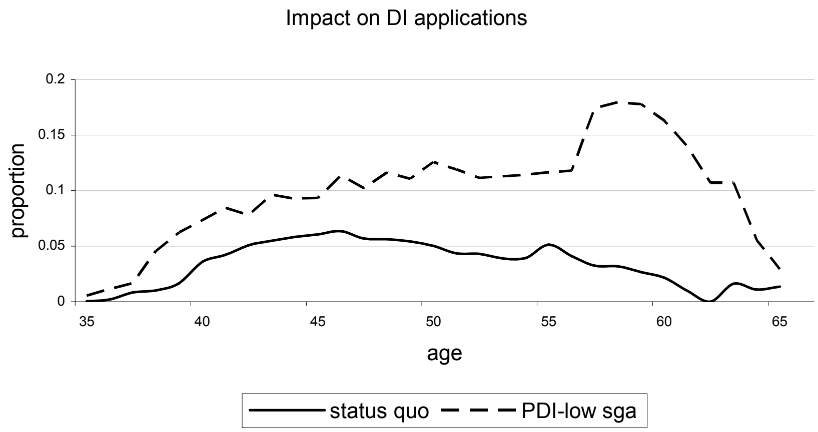


Figure 1.17: Impact on DI application (Low SGA)



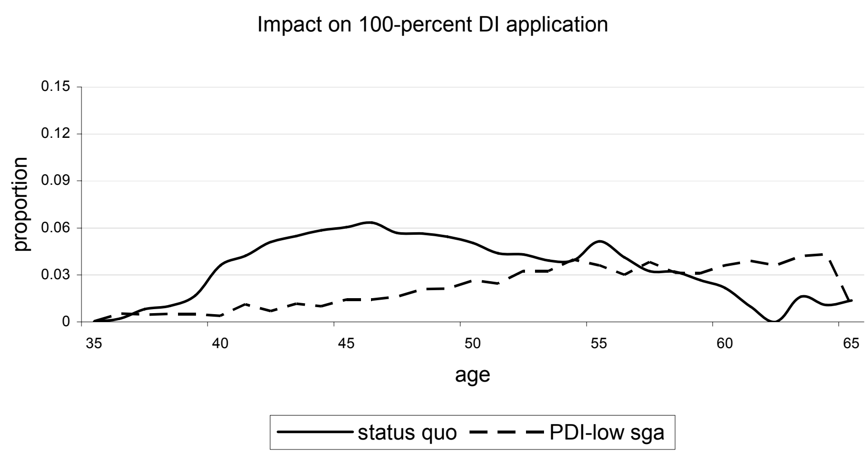
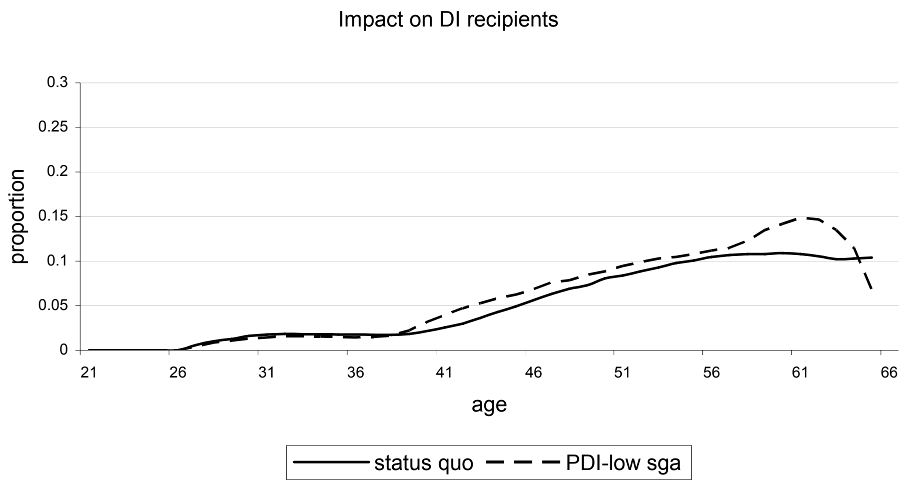


Figure 1.18: Impact on DI rolls (Low SGA)



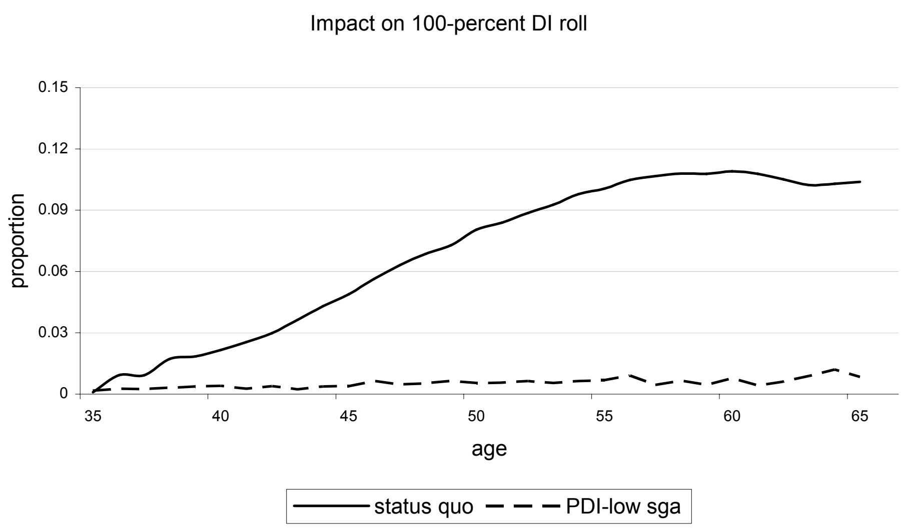


Figure 1.19: Distribution of ages of first entitlement (Low SGA)

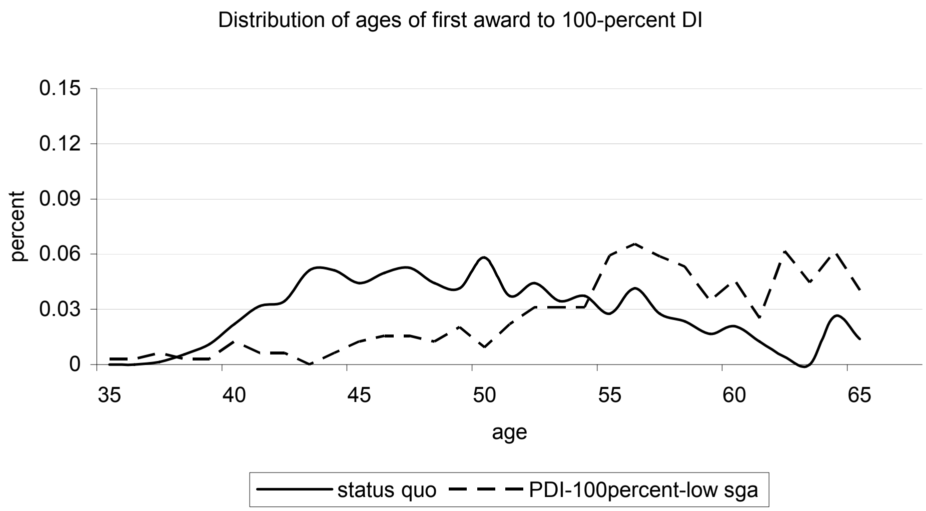
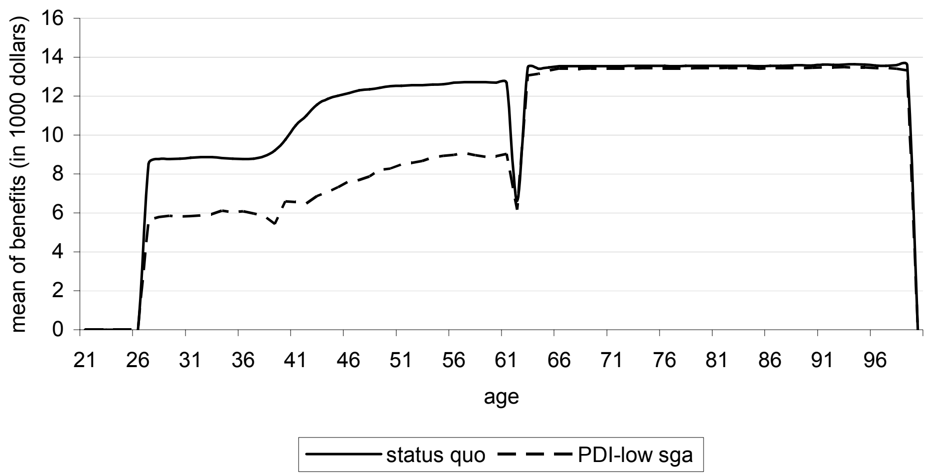
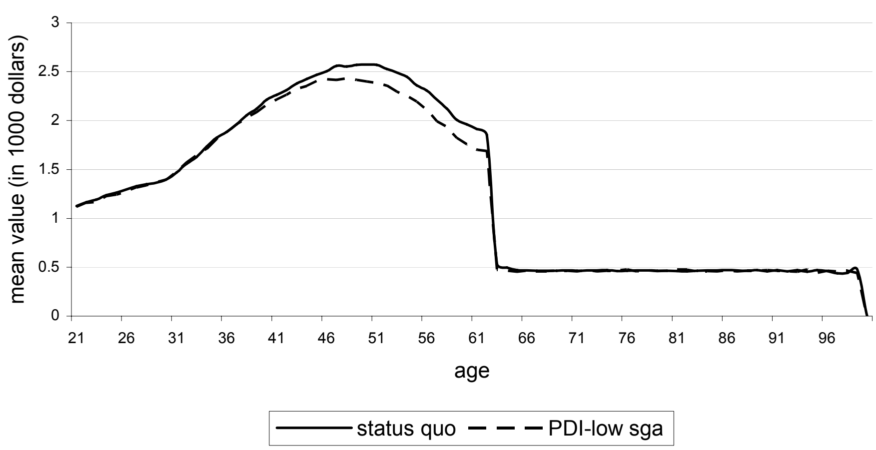


Figure 1.20: Impact on Social Security benefits and contributions

Impact on Social Security benefits (DI and OA)



Impact on Social Security contributions (by DI beneficiaries)



Appendix A:

A1. Public Contributory Disability system in some OECD Countries

Partial benefit option available	Only full benefit possible
Denmark	Australia
France	Austria
Germany	Canada
Italy	Belgium
Korea	Mexico
Netherlands	Portugal
Norway	Turkey
Poland	United Kingdom
Spain	United States
Sweden	
Switzerland	

Source: OECD database on programmes for disabled persons.

A2. The five-stage sequential determination procedure of DI

An individual's application for DI is sent to one of the 54 Disability Determination Services (DDSs), usually in the state where the applicant lives. The DDS makes its accept/reject decision according to a sequential five-stage screening procedure illustrated in the following figure. At the first stage, it is determined whether the individual has engaged in substantial gainful activity (SGA) subsequent to the claimed onset of disability. Any applicant who is found to earn in excess of the SGA threshold ($860 per month now) will be rejected at this stage. At the second stage, applicants will be denied if the impairment is not judged to be severe enough. The third stage is to determine whether the applicant's impairment meets the *Listing Impairments,* one of over 100 standardized impairment classifications. If the impairment falls into one of the categories, the applicant will be granted a *Medical Allowance*; otherwise, the applicant will be referred to the fourth stage, where the DDS evaluates the applicant's residual functional capacity to determine whether the disability prevents him/her from doing his/her previous work. Applicants will be rejected if they are judged to be able to do their past work; otherwise, the application goes to the last stage where the applicant is evaluated whether he is capable of any other type of work. If the applicant is determined not able to do any other work, he will be given a *Vocational Allowance*. The award will be given only to those applicants who are determined unable to engage in any substantial gainful activity in the national economy due to severe disability conditions, taking into account the individual's age, education, and employment history.

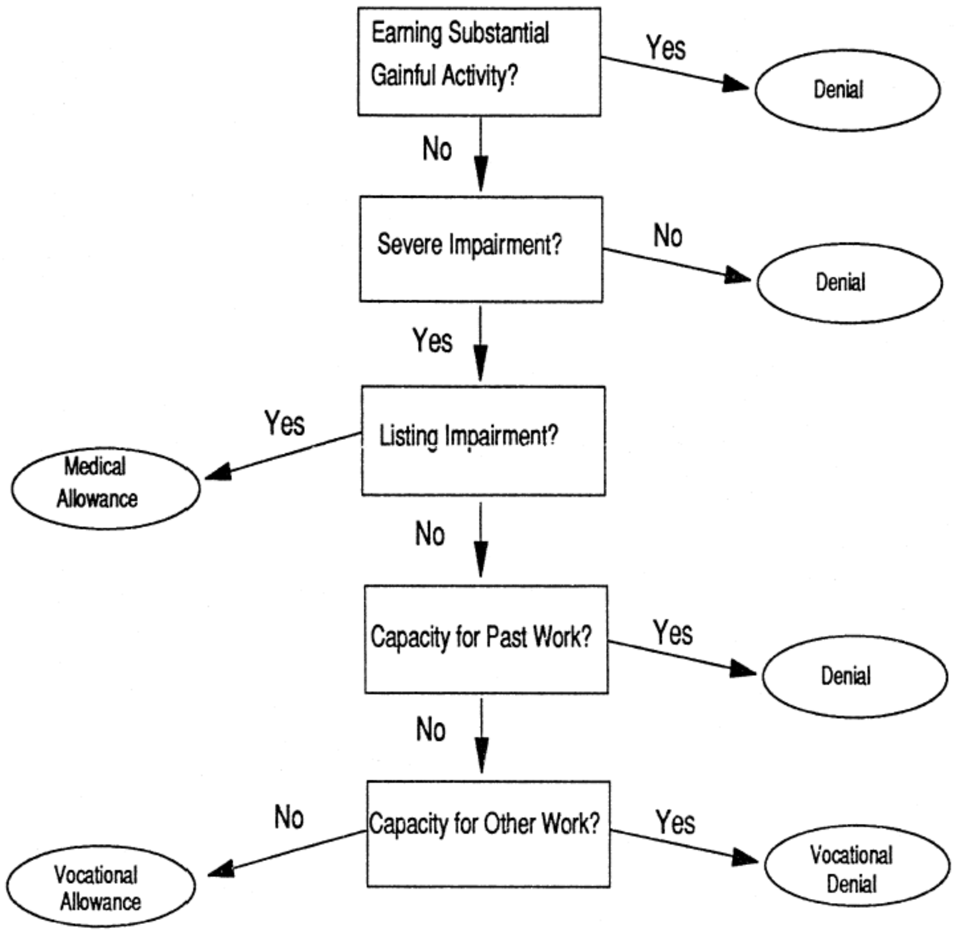


Figure A1: Five-stage Sequential Determination Process of the DI Program

(See Lahiri et al. 1995 and Benitez-Silva et al. 1999)

Chapter 2

Disability Insurance Application Decisions near Retirement Age

2.1 Introduction

The Social Security Disability Insurance (DI) program provides both cash benefits and Medicare coverage to awardees. There has an extensive literature addressing the incentive effect of *cash benefit* levels on disability application behavior. Although Medicare coverage is believed to be another important motive for disability applicants[18], it is almost impossible to study the effect of its value

[18] Health insurance is an important factor taken into consideration by a worker when he is making a decision to work or apply for disability benefits. For individuals who are disabled, health costs are quite high on average; in 2002, a DI recipient had on average $6,076 in Medicare health costs or about 52% of the average yearly DI cash benefit. The health insurance component of DI is

variation across states or across individuals on the disability application, for Medicare is a nationally-administered program and its benefits are almost standard for disability beneficiaries. Without measuring the value of this in-kind benefit, any estimation of the effect of DI benefits (cash value only) on application behavior will be biased upward.

In this study, I take a new look at the elasticity of disability application behavior to DI cash benefit levels by exploiting the little-noted fact that DI application of the 62-64 years old is driven by disability cash benefits only and

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therefore particularly valuable to these disabled individuals. DI beneficiaries must be on the disability rolls for 24 months prior to Medicare enrollment. If they become entitled to Medicare benefits and return to work by completing the trial work period and earning over $700 monthly, cash benefits are suspended but health coverage continues for at least 39 months. After this, there is an option to buy continuing Medicare coverage at a rate of $309 monthly for Hospital Insurance (Part A) and $45.50 monthly for Supplementary Medical Insurance (Part B) in year 2000. In the absence of available private insurance that provides comparable coverage without high premiums, beneficiaries may choose to discontinue efforts to sustain work.

There has been little work on the health insurance component of DI. Since Medicare is a federal program, it is difficult to obtain direct evidence of effect of the value of Medicare on DI participation. Most of literature just states this idea, but not supported by empirical evidence. Walter Y. Oi (1996), Jonathan S. Leonard (1996), and Friedland and Evans (1996) states that for many people with disabilities Medicare is more valuable than cash benefits. For some disabled workers, having a job does not mean that they can get necessary health care from employers. Besides, the private health insurance is less likely to provide health coverage of chronic or long-term sickness. Gruber and Kubik (2002) use reduced form model to investigate the effect of health insurance coverage on the decision of individuals to apply for DI. Because there is a two-year waiting period for DI beneficiaries getting Medicare after they start to receive DI benefits, the beneficiary's health need is not covered by any health insurance during those two years unless he has alternative source of health insurance, such as his spouse's health insurance. The authors find that those who have alternative sources of health insurance are more likely to apply for DI program than those who have not any other source of health insurance. They also find that limiting the waiting period would significantly increase applications to the DI program.

Beneficiaries terminated from either Medicare may have difficulty finding coverage through private insurance companies and employer-based insurance programs that do not cover the individual for pre-existing conditions. Many researchers believe that the disabled have often been frightened of returning to work and risking the loss of Medicare coverage in the absence of comparable private coverage.

Medicare coverage can not be the reason for these ages to apply for disability. Taking advantage of this special age window from 62 to 64, I am able to more precisely estimate the incentive effect of cash benefit levels on disability application behavior without worry about the possible bias caused by Medicare incentives of disability application since Medicare incentives do NOT exist in this age window. In particular, DI program grants Medicare coverage to disability awardees only after two years since the date of award. Thus, the 62-64 years old disability applicants, if approved[19], will be granted cash benefits immediately, but will be extended the Medicare coverage only after two years being on the disability roll, at which point they will be at age 65 or older when Medicare coverage is available to everybody, regardless of DI application. I infer that cash benefits offered by DI program are the main driving power for the application of the 62-64 years old. Thus, estimating the response of disability application decisions to DI cash benefit levels on this specific age window 62-64 is a natural way to separate out cash incentive effect (from health insurance effect) of DI application and get more precise estimation results than previous literature.

Disentangling cash benefits incentives and health insurance incentives of disability applicants is informative for policymakers. The Social Security Administration (SSA) has implemented a series of policy changes since the

[19] It usually takes about one year for the disability applicant to hear about the decision on their status from the local office of the Social Security Administration.

inception of the DI program. Some make use of financial incentives of DI applicants and beneficiaries to implement policy goals, such as Trial Work Period (TWP) and “$1 for $2 benefit offset”, and others are devoted to understanding health insurance motives for DI application and participation, such as Expanded Availability of Health Care Services. Nevertheless, the effects of those two types of policy changes on DI application and participation have been very difficult to differentiate. Separating cash incentives effect from health insurance incentives effect of disability application is informative for policymakers to evaluate the effectiveness of disability policy reforms.

The organization of the paper is as follows: Section II reviews previous research; Data used in this study and the construction of the sample and some variables used in the estimation is discussed in Section III; Empirical estimation strategy and results are presented in Section IV; Section V concludes.

2.2 Literature Review

Enormous research effort has been devoted to understanding the financial incentives of DI program application.

Leonard (1979) estimates DI participation instead of application due to data limitation. He includes in the estimating equation an interaction term of an estimated probability of passing the DI medical test and possible DI benefits the individual may get according to the earning records. Leonard also has in the regression a measure of past earnings. According to Leonard, an elasticity of DI program participation with respect to disability benefit levels is around 0.35. Because DI awards are usually less than DI applications, we infer that an elasticity of DI application with respect to benefit levels will be higher than 0.35.

Halpern and Hausman (1986) use data from the 1972 Survey of Disabled and Non-disabled Adults (SDNA) to estimate the responsiveness of DI applications to benefit levels and approval probabilities. The data has its advantages that it has questions on DI application and is able to be matched to individuals' Social Security earnings records. Thus, Halpern and Hausman are able to calculate individuals' possible DI benefits more precisely. In their model, the labor supply equation is linear with the decision to apply for DI benefits, a technique developed by Hausman. There is a tradeoff between DI application and work. An individual just compares the utility from applying for disability benefits and the utility from keeping working. They also include in their model an uncertainty of passing the DI medical test if one decides to apply for disability benefits. If the disability applicant passes the test, he/she gain utility from receiving disability benefits and leisure (from not working). If the applicant is rejected by the medical test, he/she will return to work but face a reduced wage level as a penalty for staying out of labor force and losing human capital while applying for DI benefits. Halpern and Hausman estimate the award probability (the probability to pass the medical test) and the reduced wage levels of the rejected applicants separately before plugging them into the DI application estimation equation. However, they use the same sample to estimate the award probability and reduced wages as to estimate the application probability, without correcting for possible sample selection biases. (I will compare their results with those in the later studies that have controlled for sample selection.) Then Halpern and Hausman simulate the responsiveness of DI application to changes in benefit levels and screening stringency (award probabilities). They find that a 20 percent increase in DI benefit levels increases DI applications by 26 percent among males, equivalent to an elasticity of application with respect to disability benefit levels of 1.3. They also find that a 20 percent decrease in the probability for males to be accepted to DI program drives down the males' DI application probability by around 4 percent, which is equivalent to an elasticity of DI applications with respect to approval probabilities of 0.2.

Bound (1987) uses a sample of 45-59 years old men from the same data used by Halpern and Hausman and also the Social Security earnings records before the onset of disabilities. His estimate of the responsiveness of the DI application probability with respect to possible DI benefits is about 0.2.

Using the 1978 Survey of Disability and Work (SDW), Kreider (1998) measures the effect of DI benefit levels and the award probability to DI program on the DI application decisions. He calculates the lifetime value of the awarded DI benefits. Kreider, putting the DI application decisions in a life cycle perspective, finds that a 10 percent increase in DI benefit levels would increase applications by 7 percent, while a 10 percent increase in the award probability would increase DI applications by 6 percent, a benefit elasticity of 0.7 and an award probability elasticity of 0.6, respectively. Kreider also discusses the possible reasons for the difference between his results and those of Halpern and Hausman. As I mentioned earlier, Halpern and Hausman use the same sample to estimate the DI award probability as to estimate the DI application decisions without correcting for sample selection biases. Their procedure is very likely to have overestimated the award probability of those who do not apply for DI benefits, if they were to apply. Kreider accounts for the self-selection to apply while estimating the DI award probability. He finds that after correcting for selection biases, the difference get much smaller between his results and Halpern and Hausman's results of application responsiveness to DI determination stringency. Kreider also points out that Halpern and Hausman do not take into account the lifetime value of the DI application decision. Accounting for the potential wage growth that non-applicants will experience in the future, his simulation results suggest that much of the difference can be explained between his estimates and those of Halpern and Hausman of the elasticity of DI applications with respect to benefits levels. It is important that Kreider incorporate the lifetime nature of DI application behavior although it is modeled in a reduced structural form screening away from the complexity of detailed incentives in the DI program. His work points out the very likely biases caused by the static point of view at disability application decisions.

Kreider (1999) estimates a structural model of DI applications and awards using 1978 Survey of Disability and Work data. He draws a sample of 40-62 years old men with reported work limitations and not on the DI rolls in 1970, and estimates their DI application probability between year 1970 and 1977. His results suggest an elasticity of DI applications with respect to benefit levels of 0.70 and an elasticity of DI applications with respect to approval rates of 0.63 for his sample over the study period. In addition, he also finds that those relatively less productive in the labor market, for example, those with higher levels of work limitations and/or with lower levels of education, are more sensitive to changes in disability benefit levels.

Kreider and Riphahn (2000) approximate a dynamic structural model of DI applications in a reduced form, a series of logit equations. They draw a sample of men and women aged 50-61 with some health limitation from the 1992 Health and Retirement Study (HRS wave 1). They study any of DI application decision, including first time application, re-application, and appeal after rejection, for those not already on DI rolls in 1986, the starting year in their study. The estimates of application behavior are done over an eight-year period between 1986 and 1993. The simulation results show an elasticity of DI applications with respect to changes in disability benefit levels of around 0.51 for males and 0.75 for females. The elasticity of DI application with respect to changes in DI approval rates between men and women is also found to be significantly different from each other, 0.67 for men and 0.26 for women. Women's disability application decisions seem to be more responsive to changes in benefit levels than men, while men's decisions are more sensitive to screening stringency than women in the study sample over the study period.

It is very difficult to identify the effect of changes in benefit amounts on DI application decisions directly through regional variations of benefit levels, since the DI program is a federal administered program and it follows the standard rules across states. Nevertheless, Black et al. (2002) identify the direct effect of financial incentives on the application decision for DI (and SSI) benefits using the regional variation in economic conditions. They use panel data on 186 counties in Kentucky, Ohio, Pennsylvania and West Virginia and study the influence of the coal boom during the 1970s and the coal bust during the 1980s on the size of DI (and SSI) rolls. Their estimates imply an elasticity of DI program payments with respect to regional area earnings of between -0.3 and -0.4. While we can presume that local economic conditions affect individuals' earning expectation and fluctuation as well as expected employment opportunities, and therefore influence their DI application decisions, the estimated coefficient on the local earnings variable may possibly pick up some other local financial factors than financial attractiveness of DI benefits as Black et al. claim in their interpretation.

Table 2.1: Previous studies on elasticity of DI application decisions with respect to benefit levels

Study	Data	Sample	Elasticity
Leonard (1979)	1972 Social Security Survey of Disabled and Non-disabled Adults (SDNA)	45-54 years old men, 1972	0.35[a]
Halpern and Hausman (1986)	SDNA	Younger than age 50 men, 1972	1.3
Bound (1987)	SDNA	45-59 years old men, 1972	0.2
Kreider (1998)	1978 Social Security Survey of Disability and Work (SDW)	45-59 years old men, 1978	0.8
Kreider (1999)	SDW	40-62 years old, 1970-1977	0.7
Kreider and Riphahn (2000)	1992 Health and Retirement Study (HRS)	50-61 years old, 1986-1993	Men:0.51 Women:0.75
Black et al. (2002)	County data (KY, OH, PA, WV)	1970-1993	0.3-0.4

[a] In this study, the elasticity is of DI *participation* (not application) with respect to benefit levels.

2.3 Data

2.3.1 Sample construction and descriptive statistics

The data used in the study are all the available eight waves in the Health and Retirement Study (HRS) from 1992 to 2006. The HRS is a biennial survey and it covers individuals born between 1931 and 1941 and their partners. The data provides extensive information on health status, employment history, wealth, family structure and also government transfers for totally 30,405 respondents.

The HRS has information on the Social Security Disability Insurance program, including the timing of application, appeal and approval, and the benefit amount received. Besides its limited sample size of disability applicants and beneficiaries[20], another issue with the data is that it does not differentiate the DI program from the Supplemental Security Income (SSI) program until wave 5 (year 2000). So when constructing my sample, I restrict the sample to the DI applicants and recipients whenever it is possible. The fact that there are still some SSI applicants and recipients in the sample that I cannot eliminate will underestimate the DI benefits levels, because the SSI is a means-tested program

[20] Some previous studies use the Social Security Administration restricted data on earning records to more accurately calculate DI beneficiaries' benefit levels and it also give a much larger sample size, but they are subject to the data's shortcoming of not having DI applicants' information. There is a restricted data on HRS cohorts' earning history but it is extremely difficult to get access to.

and its benefit levels are generally much lower than DI benefits, and overestimate the number of DI applications.

I construct the sample including all the DI applicants in eight waves. For those who ever applied but rejected and then re-apply or appeal, I treat them as a new applicant. In the age 62-64 sample, there are only several re-apply or appeal cases. The sample is restricted to those who apply for DI between year 1992 and year 2006 when the HRS interviews are conducted, so that the relevant information (health status, wealth, employment, etc.) at the time of DI application can be obtained. I eliminate in the sample those who are already receiving DI benefits when the DI application decision is estimated. Ideally I should have run a selection equation to control for this initial condition, because unobserved characteristics may affect the timing individuals decide to apply for DI. In Table 2.3, I compare the observed characteristics of DI applicants aged 62-64 (totally 176 individuals) and that of younger than age 62 applicants (1,462 individuals). The 62-64 years old applicants are more likely to be male and white than younger applicants. Interestingly, although they are older but the 62-64 years old DI applicants are less likely to report worse health and work limitation. They seem to have better health insurance coverage but they also have more out-of-pocket medical expenses than the applicants below age 62. Financially they are doing better, for example, their household wealth and income are much higher than younger applicants. The 62-64 years old applicants have lower predicted probability to be granted DI benefits than those applicants below age 62, but would have much higher predicted benefit levels than younger applicants. Of course, we do not know whether they would still get higher DI benefits or not if they were to apply earlier in their life cycle, say, before age 62. The higher benefit levels can be related to the improvement of earning history at older ages.

I also present in Table 2.4 the comparison statistics between 62-64 years old DI applicants and non-applicants at the same age range. Between age 62 and 64, the DI applicants are more likely to be non-white and less likely to complete high school education. They are less likely to be married at the time of interview and possibly separated, divorced or never married. The job they held the longest tenure is less likely to be white collar occupation. Those of them who report work limitation are almost four times as many as the non-applicants who claim to be work limited. More of applicants self report to be in poor health than those of non-applicants who do so. Less of applicants have any health insurance coverage than non-applicants, but applicants' average out-of-pocket medical expenses are more than double of those of non-applicants. The total net wealth of household of applicants, on average, is less than one-third of that of non-applicants, and the total household income is less than two-third compared to non-applicants. The predicted probability of DI approval for non-applicants, if they were to apply, is about one-third of the probability for applicants. However, the non-applicants would get higher (predicted) disability benefit levels than current applicants. It may be related to their higher work earning history, which might be endogenous to their DI non-application decision.

2.3.2 Predicted Variables

According previous literature and the theoretical model elaborated in the previous chapter, the DI application decision is affected by the expected benefit amounts, the expected probability of being approved, health status, other financial variables and some unobserved characteristics that affects preference and may be related to some of the observed variables, such as age, gender, race, education, marital status and family structure. I also have region dummies in the model to capture the local economics conditions that may affect people's expectation of earning opportunities and therefore their DI application decisions, as discussed in literature review section. The region dummies can also capture part of the leniency of the local DI determination offices since the variations of DI award rates across states/regions are significant (See Yin, 2004).

I applied technique used in Kreider (1999b) to construct a binary work limitation index, which proves to be a good proxy for work disability. The index is predicted using a series of health conditions and functional limitations in Activities of Daily Living (ADL). The estimation results are presented in the Appendix Table B1. Following Kreider and Riphahn (2000), I use sub-samples to predict the probability of being granted DI benefits and the expected DI benefit levels, both of which are then used in the main logit estimation of DI application. The prediction equations and results are shown in the Appendix Table B2 and B3, respectively. While estimating the probability of being approved, I control for the sample selection from DI application. The correction for selection biases from both application and award decisions has been accounted for in the estimation of DI benefit amounts. In the application decision equation, the exclusion variable is the health insurance provided by last employer, which affects employment decision and DI application decision but does not directly affect the DI award decision. In the approval decision equation, the exclusion variable is the work limitation indicator that influences the determination of DI eligibility but is not directly related to the calculation of DI benefit amount a person can get if approved. One's DI benefit amount is calculated based on his/her whole earning history.

2.4 Estimation and Simulation Results

First I restrict the sample to be the same as in Kreider and Riphahn (2000) to be those age 51-62 with some health limitation and use only wave 1 of the HRS. The estimation and simulation results of application decisions are very similar to those in Kreider and Riphahn (2000). Then I proceed to estimate the DI application equation using the sample of my interest, those 62-64 years old. I present the logit estimation results of the DI application decision in Table 2.6. Based on the predicted application probabilities from the logit specification, I simulate the effect of changes in the key policy variables, benefit levels and the probability of being awarded, on the mean application probability. The simulation results of benefits changes are summarized in Table 2.7. We see that a 20 percent decrease in disability benefit amount results on average in 2 percent drop in mean predicted application probabilities for men and only 0.1 percent decline for women, which are equivalent to an benefit elasticity of 0.1 and 0.005 for men and women, respectively. Compared to previous literature, this study finds a much lower elasticity of application with respect to disability benefit levels for both males and females. Especially women at age 62-64 are barely responsive to the benefit cuts while making their DI application decisions, which is contrast to the findings for a younger sample (age 51-62) in Kreider and Riphahn (2000) that women are more sensitive to disability benefit level changes than men. The effects are non-linear in that the same magnitude of benefit *increase* (20 percent) leads to bigger changes (2.8 percent and 0.2 percent) in application rates among both men and women, equivalent to an elasticity of 0.14 for males and 0.01 for females, still much lower than those found in previous studies. Women again tend to be less responsive to the benefit changes.

The elasticity of application with respect to DI benefit levels at age 62-64, on average, is much lower than that of application at younger ages summarized in previous studies. It is very likely to be the lower bound of the responsiveness of general population's application behavior to disability benefit level changes when health insurance incentives do not exist, due to the fact that the expected cash flow of disability benefits will be generally shorter for the 62-64 years old applicants, the oldest possible DI applicants, than younger applicants, and that retirement benefits start to kick in so that income effects are not dominant (cash benefits incentives for disability benefits are weakened) while substitution effects become more important when those near retirement age weigh their retirement benefits and disability benefits. The latter effect can only be measured accurately in a structural model characterizing in details the incentives of both DI and OA program as well as the complexities when the two programs interact with each other closely between age 62 and 64.

I also simulate the DI application response to changes in the probability of being approved. The results are summarized in Table 2.8. A 20 percent decrease in the probability of being awarded results in 5.6 percent drop for men and only 0.1 percent decline for women in their mean predicted probabilities of applying. The same magnitude of 20 percent increase in approval probabilities drives up the mean application rate by 7.4 percent for men and as low as 0.1 percent for women. The results are much lower than the elasticity calculated in previous literature (0.4

in Parsons, 1991; 0.2 in Halpern and Hausman, 1986; 0.63 in Kreider, 1999a). Moreover, my results are at odds with what Kreider and Riphahn (2000) show that women, compared to men, are less responsive to changes in the probability of being awarded (an elasticity of 0.26 for women vs. 0.67 for men) but more responsive to the benefit level changes (an elasticity of 0.75 for women vs. 0.51 for men). In this study, men aged between 62 and 64 tend to be much more responsive to changes in both benefit levels and award probabilities than 62-64 years old women. This may be related to the fact that men generally have higher earnings history than women, which result in higher disability benefit amounts for men than for women. A 20 percent change in benefit levels will lead to a much larger change in absolute values for men than for women. Presumably, higher earners are more responsive to benefit changes than low earners. We also find that men's DI application decisions tend to be more sensitive to changes in award probabilities than to changes in benefit levels, which is in line with Kreider and Riphahn (2000) but contrasts with Halpern and Hausman (1986) finding using a sample of younger men than those in this study that men's DI application decisions are hardly affected by changes in the award probability.

2.5 Conclusion and Discussion

This study takes advantage of a special age window, from age 62 to 64, to re-calculate the elasticity of DI application decisions with respect to changes in its cash benefit values. It is a natural experiment to separate out the effect of Medicare value offered by DI program on application behavior, which allows me to more accurately measure the cash incentive of applying for DI program. Not surprisingly, I find lower elasticity of application with respect to disability cash benefit level changes than the estimates in previous literature. The 62-64 years old are the oldest possible DI applicants. Their responsiveness to benefit changes can only be regarded as a lower bound, if there is any, of the cash elasticity of disability application in general. In particular, this oldest applicants group is facing a shorter life horizon ahead than younger applicants to enjoy their potential disability benefits if awarded. In addition, Social Security retirement benefits start to be available to them (at a reduced level due to the Actuarial Reduction Factor on early retirees' retirement benefits). Therefore, DI benefits are presumably less attractive to them especially considering the Medicare value of DI program is gone for the applicants at their age. Of course, one may argue that Social Security early retirement benefits are not as attractive as DI benefits since they are at a lower level than potential DI benefits for an eligible individual. However, the uncertainty and costs (lost wages, psychic cost, and hassle cost) involved in the

DI application process may be overwhelming for some people. Within the current reduced form context, I assume that the effect of the early retirement penalty and the effect of the uncertainty and costs in DI application process offset each other while people are making Social Security application decisions. Although DI benefits are less attractive for people aged 62-64, the simulation results show that they still tend to respond to benefit changes. It implies that cash incentives of DI program can be significant for younger applicants[21]. The previous studies focus on younger applicants but do not usually model the Medicare values of DI program, which make their results an overestimates of DI program's cash value in application incentives.

However, due to the data limitation, the work recency eligibility has not been accounted for in this study. Women are less likely to satisfy the recency work requirements of DI program (Leonesio et al. 2003), which may explain some of the non-applications and low responsiveness to policy changes among females. Another issue, also endemic to all cross-sectional studies is that the estimates are only a short-run effect. The effect of policy changes may take time to be seen in people's responses. So the estimates in this study may have underestimated the responsiveness of application decision to changes in policy variables in the long run if it were put in a dynamic model. Moreover, if it is

[21] There is a little-noted fact mentioned in Fronstin (2000) that cash benefits provided by DI program can be used be the awardees to purchase COBRA coverage during the two years waiting period on the DI rolls for Medicare coverage.

possible that the policy changes alter the underlying behavioral structure, according to Lucas critique (1976), reduced form models cannot measure properly the effect of policy changes on behavior any more. Instead, a dynamic structural model should be used to characterize in details the program incentives and study the implications of policy changes on behavior. So it is necessary to re-analyze the question in this study in a life-cycle structural model that details incentives of disability program and retirement program and more properly estimate the total effect of policy changes on disability application decisions.

Table 2.2: Variable Definitions

Variable	Definition
Age	Respondent's age at the time of interview
Ageapply	Respondent's age in the year of DI application
Born31-33	Cohort born between 1931 and 1933
Born34-36	Cohort born between 1934 and 1936
Born37-39	Cohort born between 1937 and 1939
Work limitation	=1 if work limited, constructed proxy for disability
High blood pressure	=1 if high blood pressure currently
Diabetes	=1 if diabetes currently
Cancer	=1 if treated for cancer last year
Lung	=1 if ever diagnosed of lung disease
Heart	=1 if heart problem
Stroke	=1 if ever had a stroke
Psychological	=1 if have psychological or emotional condition
Arthritis	=1 if ever diagnosed of arthritis
Back	=1 if have back problem
Walk across room	=1 if have difficulty walking across room
Dress	=1 if have difficulty dressing without help
Bath without help	=1 if have difficulty bathing without help
Eat without help	=1 if have difficulty eating without help
Get in/out of bed	=1 if have difficulty getting in/out of bed without help
Walk one block	=1 if have difficulty walking one block
Walk several blocks	=1 if have difficulty walking several blocks
Sit two hours	=1 if have difficulty sitting for two hours
Feel depressed	=1 if often feel depressed, not enjoy life

Table 2.2: Variable Definitions (Continued)

Variable	Definition
Sleep/rest well	=1 if have difficulty sleeping/resting well
Self-reported health	=1 excellent; =2 very good; =3 good; =4 fair; =5 poor
Health insurance coverage	=1 if have any kind of health insurance
Prob. of DI approval	Predicted probability of being awarded if apply
Predicted DI benefits	Predicted benefit levels
Predicted earnings	Predicted annual labor income
Predicted SS retirement benefits	Predicted Social Security retirement benefit levels
Net household wealth	Sum of non-housing wealth less debt
Net household income	Sum of all household income
Married	=1 if married at the time of interview
Schooling	Years of schooling
White collar	=1 if occupation is professional or managerial before onset of disability
Northeast	=1 if respondent live in the northeast
Midwest	=1 if respondent lives in the midwest
West	=1 if respondent lives in the west
South	=1 if respondent lives in the south

Table 2.3: Descriptive Statistics: comparison between 62-64 years old DI applicants and younger than 62 years old applicants

Variable	Aged 62-64 (N=176)		Age below 62 (N=1462)	
	Coefficient	Std. Dev.	Coefficient	Std. Dev.
Age	62.67	0.78	55.30	4.52
Ageapply	62.23	1.30	54.8	5.37
Born31-33	0.29	0.45	0.10	0.31
Born34-36	0.19	0.40	0.16	0.37
Born37-39	0.18	0.38	0.23	0.42
Male	0.47	0.50	0.40	0.49
White	0.71	0.45	0.67	0.47
Married	0.62	0.49	0.62	0.48
Schooling	11.12	3.46	11.02	3.09
White collar	0.56	0.49	0.52	0.49
Work limitation	0.82	0.38	0.84	0.37
Self-reported health	3.92	0.95	3.96	1.02
Health insurance coverage	0.89	0.30	0.81	0.39
Out-of-pocket medical expenses	4868.7	9488.4	3413.7	12286.5
Prob. of DI approval	0.13	0.07	0.18	0.08
Predicted DI benefits	7492.5	1479.3	6737.3	1243.3
Net household wealth	93567.3	190269.5	55784.0	180490.9
Net household income	36651.7	63918.8	29603.3	35540.52
Northeast	0.16	0.36	0.16	0.36
South	0.50	0.50	0.49	0.50
Midwest	0.19	0.40	0.21	0.41
West	0.15	0.36	0.14	0.34

Table 2.4: Descriptive Statistics: comparison between DI applicants and non-applicants at age 62-64

Variable	Applicants (N=176)		Non-applicants (N=9627)	
	Coefficient	Std. Dev.	Coefficient	Std. Dev.
Age	62.67	0.78	62.60	0.63
Ageapply	62.23	1.30	54.23	7.70
Born31-33	0.29	0.45	0.22	0.42
Born34-36	0.19	0.40	0.22	0.42
Born37-39	0.18	0.38	0.21	0.41
Male	0.47	0.50	0.47	0.50
White	0.71	0.45	0.81	0.39
Married	0.62	0.49	0.73	0.44
Schooling	11.12	3.46	12.21	3.23
White collar	0.56	0.49	0.61	0.49
Work limitation	0.82	0.38	0.23	0.42
Self-reported health	3.92	0.95	2.70	1.11
Health insurance coverage	0.89	0.30	0.93	0.25
Out-of-pocket medical expenses	4868.7	9488.4	2314.7	7007.9
Prob. of DI approval	0.13	0.07	0.04	0.06
Predicted DI benefits	7492.5	1479.3	7831.1	1388.09
Net household wealth	93567.3	190269.5	296609.6	1812481.0
Net household income	36651.7	63918.8	57796.8	102737.3
Northeast	0.16	0.36	0.17	0.37
South	0.50	0.50	0.42	0.49
Midwest	0.19	0.40	0.24	0.43
West	0.15	0.36	0.17	0.37

Table 2.5: Descriptive Statistics: the 62-64 years old not already receiving DI benefits

Variable	Men (N=4,618)		Women (N=5,185)	
	Coefficient	Std. Dev.	Coefficient	Std. Dev.
Age	62.98	0.82	62.96	0.81
Ageapply	63.03	1.10	62.93	0.70
Born31-33	0.22	0.45	0.24	0.43
Born34-36	0.23	0.42	0.24	0.43
Born37-39	0.21	0.40	0.22	0.41
White	0.83	0.37	0.80	0.39
Married	0.82	0.38	0.64	0.44
Schooling	12.33	3.40	12.08	3.04
White collar	0.49	0.50	0.71	0.44
Work limitation	0.22	0.23	0.26	0.27
Self-reported health	2.69	1.10	2.70	1.11
Health insurance coverage	0.94	0.24	0.93	0.26
Out-of-pocket medical expenses	2053.9	4784.1	2651.1	7939.5
Prob. of DI approval	0.35	0.10	0.36	0.09
Predicted DI benefits	8183.1	1411.7	7595.0	1315.4
Net household wealth	328805	203463	273837.4	176119
Net household income	64745.4	10619.1	50246.7	83592.9
Northeast	0.17	0.37	0.17	0.37
South	0.42	0.49	0.42	0.49
Midwest	0.24	0.43	0.25	0.43
West	0.17	0.37	0.16	0.37

Table 2.6: Logit Estimation of DI Application Decision among 62-64 years old

	Men (N=4,618)		Women (N=5,185)	
	Coefficient	Std. Err.	Coefficient	Std. Err.
Ageapply	1.032	1.048	9.285	3.076
Ageapply^2	0.000	0.009	-0.068	0.024
White	-2.553**	0.852	-0.983	0.823
Married	1.620	1.272	1.622	1.289
Schooling	-0.936*	0.395	0.185	0.404
Work limitation	0.388*	0.176	1.950*	0.772
Health Insurance Coverage	-0.676	0.813	-0.737	0.662
# children	-0.002	0.079	0.068	0.091
Predicted DI benefits	0.004**	0.001	0.002″	0.001
Predicted prob. of DI approval	5.048**	1.220	9.704	19.189
DI benefits * Prob. of DI approval	0.004**	0.001	0.003″	0.001
Predicted earnings	-0.001**	0.00003	-0.0004	0.0003
Total household wealth	0.0017**	0.0005	-0.0002	0.0011
Northeast	-1.559*	0.753	0.201	0.977
South	-1.767*	0.699	-0.250	0.761
West	-0.361	0.662	-0.891	1.043
Born31-33	-0.745	0.467	-1.224	0.839
Born34-36	-0.432	0.617	-0.913	0.978
Born 37-39	0.821	0.650	-1.113	1.058

Table 2.6: Logit Estimation of DI Application Decision (Continued)

	Men (N=4,618)		Women (N=5,185)	
	Coefficient	Std. Err.	Coefficient	Std. Err.
Year94	-0.748	0.701	-2.915	1.412
Year96	0.224	0.689	-1.083	1.305
Year98	-0.347	0.604	0.624	0.844
Year00	0.251	0.643	-0.169	0.727
Year02	-1.299	0.781	-0.270	0.803
Year04	0.014	0.921	-0.249	0.909
Year06	1.001	0.834	0.636	0.781
Constant	-37.310	31.259	-306.226	96.332
Log likelihood	-110		-83	

Note: **, *, and ″ indicate significance at 1 percent, 5 percent, and 10 percent level, respectively, for all tables in the paper.

Table 2.7: Simulation of the Effect of Benefit Level Changes on DI Application Probability

	Men	Women
Benefits changes	Application probability	
-20 percent	-2.0 percent	-0.1 percent
+20 percent	+2.8 percent	+0.5 percent

Table 2.8: Simulation of the Effect of Award Probability Changes on DI Application Probability

	Men	Women
Award Prob. Changes	Application probability	
-20 percent	-5.6 percent	-0.1 percent
+20 percent	+7.4 percent	+0.4 percent

Appendix B:

Table B1: Probit Estimates for Binary Work Limitation Index

Variable	Coefficient	Std. Err.
High blood pressure	-0.109**	0.019
Diabetes	0.066**	0.025
Cancer	-0.006	0.025
Lung	0.227**	0.027
Heart	0.164**	0.013
Stroke	0.262**	0.031
Psychological	0.203**	0.023
Arthritis	0.060**	0.019
Back	0.337**	0.013
Walk across room	0.273**	0.038
Dress	0.281**	0.030
Bath without help	0.517**	0.038
Eat without help	0.564**	0.060
Get in/out of bed	0.341**	0.031
Walk one block	0.338**	0.025
Walk several blocks	0.733**	0.017
Sit two hours	0.321**	0.015
Feel depressed	0.082**	0.017
Sleep/rest well	0.122**	0.014
BMI < 20	0.152**	0.031
25 <= BMI < 30	-0.054**	0.015
BMI >= 30	-0.017	0.017

Table B1: Probit Estimates for Binary Work Limitation Index (Continued)

Variable	Coefficient	Std. Err.
#condition * schooling	0.015**	0.001
#condition * white collar	0.008	0.010
Age	0.044**	0.007
Age squared	-0.0003**	0.000
Schooling	-0.038**	0.012
Schooling * age	-0.0002	0.0002
Non-white	0.051**	0.016
Married	-0.052**	0.015
White collar	-0.188**	0.022
# residents in household	-0.024**	0.005
# children	0.003	0.003
Northeast	-0.042*	0.019
West	0.144**	0.019
South	-0.004	0.016
Constant	-2.345	0.254
Log likelihood / Obs.	-3408	9803

Table B2: Prediction Equation for the Probability of DI Approval

Variable	Coefficient	Std. Err.
Ageapply	-0.04	0.11
White	-0.02	0.28
Schooling	-0.031	0.04
Married	0.67	0.88
South	0.15	0.22
White collar	-0.14*	0.02
Work limitation	0.18**	0.04
λ_{apply}	0.56	0.97
Constant	31.05**	50.74
Log likelihood / Obs.	-10050	9803

Table B3: Equation to Predict DI benefits Controlling for Selection of Application and Award Decisions

Variable	Coefficient	Std. Err.
Age	0.02	0.03
White	0.11*	0.05
Schooling	0.05**	0.00
Married	0.09*	0.04
South	-0.09	0.56
White collar	0.10	0.42
λ_{apply}	0.32	0.73
$\lambda_{approval}$	-0.30	0.51
Constant	-2.93	6.42
R^2 / Obs.	0.13	574

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