

Disability Insurance Applications near Retirement Age †

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Abstract

The literature estimating the effect of benefit levels on the Social Security Disability Insurance (DI) application decisions has not been able to separate the effect of Medicare coverage provided by the program on application decisions from the effect of cash-benefits, and therefore previous estimates are likely to be overstated. In this research we compute the elasticity of DI applications with respect to cash benefit levels focusing on the special age window between the Early Retirement Age (ERA) and Normal Retirement Age (NRA) in which Medicare incentives are virtually non-existent. This approach allows us to more accurately estimate the effect of cash benefits on the decision to file for disability benefits. The responsiveness of DI applications to policy variable changes is simulated in a life cycle structural framework that characterizes in detail the rules of the Social Security programs. We find that the benefit elasticity of DI applications at age ERA-NRA is much higher than that at younger ages. We also find some interesting dynamic effects, such as the changing age structure of applicants and the application timing shift when there are changes in policy variables.

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1. Introduction

The Social Security Disability Insurance (DI) program is the primary cash transfer program for the disabled in the United States. It provides partial earnings replacement to workers who lost earnings capacity due to severe and long-term disabilities. There is an extensive literature estimating the effect of disability benefit levels on DI application decisions. Existing studies mostly focus on older workers at ages below 62.¹ One reason for this is to avoid modeling the complex program incentives and individual decisions when the Social Security Old Age (OA) benefits start to be available at age 62. These studies have come to different conclusions about the magnitude of the responsiveness (elasticity) of DI application with respect to DI benefit levels. The estimated elasticity varies widely from 0.35 (Leonard, 1979) to 1.3 (Halpern and Hausman, 1986).

Another important benefit provided by the DI program is Medicare coverage two years after the cash benefits are awarded. However, it is almost impossible to distinguish the effect of Medicare coverage from the financial incentives. This important in-kind benefit is rarely modeled while estimating the effect of DI benefits on DI application. Since Medicare is a federally-administered program, its benefits are standard for disability beneficiaries. There are few variations in its benefits across states or across individuals as noted in Bound and Burkhauser (1999). Not being able to measure the effect of Medicare coverage on DI application will lead to bias in the estimation of the effect of DI cash benefits on DI application.²

In the paper, we re-estimate the elasticity of disability application probability with respect to DI cash benefit levels focusing on the special age window between the Early Retirement Age (ERA) and the Normal Retirement Age (NRA). This is a quasi-experiment to estimate the effect of cash benefits on DI applications without having to worry about potential biases caused by not considering the effect of Medicare incentives on applications. According to the Social Security Administration (SSA) Annual Statistical Supplement (2009), approximately 142,817 workers

¹ The sample in Lahiri, Song and Wixon (2008) includes age 18 to 64.

² One exception is the work by Lahiri, Song and Wixon (2008) that predict the expected value of Medicare coverage for DI applicants.

aged 62-64 applied for DI benefits in 2008 and 54,842 of them were awarded the benefits.^{3, 4} DI applications between ERA and NRA, ($\text{age} \in [62, \text{NRA})$), are mainly driven by DI cash benefits when Medicare coverage is probably not the main reason for these ages to apply for disability. The reasoning is as follows: The DI program grants Medicare coverage to disability awardees only two years after the date of award. Thus, a disability applicant between ERA and NRA, if approved, will get Medicare coverage only after staying two years on the DI rolls, at which point they will almost surely have reached age 65 when Medicare coverage is automatically made available, regardless of whether they applied for disability.⁵ Therefore an individual who applies for DI benefits between ERA and NRA does so mainly for cash benefits of the DI program. Thus, estimating the elasticity of DI application between the ERA and the NRA, when Medicare incentives of the DI program are virtually non-existent, helps separate out the Medicare incentive effect from the cash incentive effect. This empirical design allows us to get more precise estimates of the elasticity of DI applications with respect to DI cash benefit levels.

In an empirically grounded life-cycle structural model that characterizes in detail the DI program incentives as well as the OA program rules, we simulate the effect of changes in policy variables, such as benefit amount and award probability, on DI application probability. It is appropriate to simulate such behavioral effects in a dynamic structural framework, especially if it is possible that the policy changes alter other parameters that govern people behavior, and according to Lucas critique (1976), reduced form models can hardly capture the whole effect (direct effect from the change in the policy of interest and indirect effect from the change in other parameters caused by that policy change) of policy changes on behavior. It is also important to characterize not only the DI rules but also the OA program rules in the model in order to predict individuals' behavior. At an age between ERA and NRA, both OA and DI benefits are available. Before ERA, only DI is available to apply. DI benefits will convert to OA rolls at NRA. The interaction between OA and DI will be discussed in detail in Section 3 and 5.

³ We have calculated this using the number of beneficiaries at age 62-64 (54,842 according to the SSA Annual Statistical Supplement Table 6.C2) and ratio of awards to applications (38.4% in 2008 according to the SSA Annual Statistical Supplement Table 6.C7). We assume that the award probability is constant for all the ages, which may result underestimation of the award probability at older ages such as age 62-64. This underestimation would cause overestimation of the number of applicants at older ages.

⁴ The number of disability awardees, once including their eligible dependents, will be larger.

⁵ On average it takes about one year for the disability applicant to hear about the decision on their status from the Social Security Administration.

Based on the simulation results from our dynamic structural model, we calculate the elasticity of DI applications with respect to the policy variable changes. What we find are summarized as follows:

- Our estimated benefit elasticity (and award probability elasticity) at age 62 to NRA, when Medicare incentives are virtually non-existent, is much higher than that at younger ages (age 21 to 61).

- In general the DI award probability elasticity is higher than the DI benefit elasticity. That is, people are more responsive to changes in the approval probability than changes in benefit amounts.

- DI application probabilities do not respond symmetrically to benefit (or award probability) reductions and increases of equal amounts.

- We also find some interesting dynamic effects in our life cycle structural framework, such as the changing age structure of applicants and the application timing shift when there are changes in policy variables.

There are advantages of using life cycle structural model over reduced-form model in simulating the behavioral responses to changes in policy measures and estimating the elasticity. We'll discuss two main aspects here.

First, the simulation exercise in a reduced-form context is essentially to keep all the other covariates constant while changing the benefit amount (or the approval probability) and see how DI application propensity will respond. However, changes in benefit amounts or approval probabilities may likely lead to changes in other covariates. For example, if benefit amount is increased, it will probably attract more applicants, and therefore the socioeconomic composition of the new sample (a pool of the original sample and the newly entered applicants) will be different. If that is the case, the simulation using the reduced-form model on the original sample will lead to biased estimation. The issue could be addressed potentially by a well-designed social demonstration project or a well-built life cycle structural model. In the paper, we attempt to apply the second approach and conduct the simulation exercises.

Second, the elasticity of DI application probability estimated by a reduced-form model (e.g. probit) is the average responsiveness at all ages in the sample to changes in policy parameters. It

averages out the different behavioral responses at different point of the life cycle. While some studies focus on some specific age group and estimate the elasticity of DI application, it may have missed the application timing effect. For example, if a study sample is restricted to age 55-60, the simulation using such an age-restricted sample to predict the application response to benefit changes implicitly assumes that the benefits are unchanged for the ages that are out of the age range of the sample, in this example, ages younger than 55 and ages older than 60. When the benefits increase for the sample (age 55-60), besides the direct behavioral response from the individuals in the sample, individuals at other ages, mainly those younger than 55, are likely to wait to apply for higher benefits. The elasticity estimate from a reduced model is mostly a short-run responsiveness to benefit changes but hardly capture the long-run effect due to the “induced entry” (apply at age 55-60) from other ages. This could be addressed by simulations conducted in a life cycle structural model where the timing effect of DI application could be examined.

Disentangling the effects of DI cash benefits incentives and the effects of DI health insurance incentives is informative for policymakers. The SSA has implemented a series of policy changes since the inception of the DI program to improve work incentives among the disabled, including changing the financial incentives (such as Trial Work Period, changing Substantial Gainful Activity level), and modifying the Medicare incentives (such as Expanded Availability of Health Care Services and the currently conducted demonstration project called Accelerated Benefits for DI beneficiaries). However, the effects of those two types of policy changes have been very difficult to differentiate, and the effectiveness of those disability policy changes has been hard to evaluate. The analysis of DI application between ERA to NRA will shed some light on the effect of DI cash benefit and is informative for policy makers while gauging the effectiveness of disability policy reforms.

The organization of the paper is as follows: Section 2 discusses the specification and solution of the life-cycle structural model; Data used to calibrate the model and the calibration results are presented in Section 3; Section 4 discusses the simulation results of the effect of policy changes on DI applications.

2. A Life-Cycle Structural Model

2.1. Model Specification

An individual chooses how much to consume, how much to work, and whether to apply for Social Security OA/DI benefits in each period to maximize the expected present value of utility over his life time.

Time. Time t is discrete and each period is one year. The model starts from age 21 when an individual is assumed to begin to decide whether or not to enter the labor force. There is a finite horizon, age 100, when death is certain.

Health and mortality. Health status, indexed by h_t , is assumed to be exogenous. $h_t=0$ denotes excellent/good health; $h_t=1$ denotes fair/poor health; and $h_t=2$ denotes being disabled.⁶ One's health status evolves between the three statuses. Survival probabilities $\pi_t(\text{age}, h_t)$ are age and health specific. Survival probabilities decrease as age increases and health deteriorates.

Labor supply. An individual makes decisions on how much to work in each period. We define labor supply (leisure) a discrete choice variable.⁷ The leisure choice (labor supply choice) takes five values. The amount of waking time one spends in leisure is normalized to 1. That is, $l_t=1$ when one is not working at all. One that works 2080 hours per year⁸ is defined as full-time working and the proportion of awake time he allocates to leisure per year is $l_t=0.525$, while the other levels of leisure, 0.644, 0.763, 0.881, correspond to part-time working.⁹

Social Security decisions. 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 OA benefits; $ssd_t=2$ when he decides to apply for DI benefits; $ssd_t=0$ denoting applying to neither of the programs. Social Security choice sets are different by ages, as shown in the table below.

⁶ Being disabled is referred to being prevented from work completely by severe health conditions or functional limitations.

⁷ The probability of being laid off or becoming unemployed is not modeled.

⁸ An individual is assumed to work 40 hours per week and 52 weeks per year.

⁹ $l_t = (12*365 - 2080)/(12*365) = 0.525$ corresponding to full-time work; $l_t = (12*365 - 1560)/(12*365) = 0.644$ corresponding to part-time work (75% of full-time work); $l_t = (12*365 - 1040)/(12*365) = 0.763$ corresponding to part-time work (50% of full-time work); and corresponding to part-time work (25% of full-time work).

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

The Early Retirement Age (ERA), which is 62, is the earliest age when individuals can claim their Social Security OA benefits but the benefits are subject to an actuarial reduction. The Normal Retirement Age (NRA) is when to claim and receive 100 percent Primary Insurance Amount (PIA). The NRA is age 65 in the model.¹⁰ Individuals who claim OA benefits later than their NRA will receive higher benefits through Delayed Retirement Credits (DRC) until age 70, the Maximum Retirement Age (MRA), when no further credit will be allowed to later claiming.

An individual makes decision to apply for DI benefits before reaching his NRA, at or above which age DI benefits are not available anymore, and the DI beneficiaries automatically convert to OA benefits. At ages between ERA and NRA, an eligible individual could choose to apply to the DI program or OA program.¹¹ (A detailed discussion will be provided shortly on the interaction of OA and DI programs for this age range.) An individual at or above his NRA and still below the MRA faces only one program option: to claim OA benefits, if an individual has not done so by then and his OA benefits will be increased permanently through DRC. The MRA, age 70, is assumed to be an absorbing state and everybody is assumed to have already been on the OA rolls by then, since there's no further benefit from delaying claiming after the MRA. Notice that the initial OA benefit claiming is an irreversible choice. That is, an individual won't leave the OA roll once he is on it, although the benefit can vary over time due to the earnings test and posterior adjustments for benefits lost due to earnings test.

Social Security benefits. The DI and OA benefits ssb_t are determined by a function $ssb(AIME_t, age_t, wage_t)$. As discussed earlier, Average Monthly Indexed Earnings

¹⁰ The majority cohorts in the data reach their NRA at age 65.

¹¹ The SSA allows eligible individuals to file for OA and DI benefits at the same time. In that case, individuals receive their early retirement benefits while waiting for determinations on their DI applications, and they could transfer to the DI roll if the latter awards higher benefits.

(AIME) summaries one's earnings history and is used in a piece-wise linear formula to compute the Primary Insurance Amount for OA and DI beneficiaries. *Age* is one argument in the benefit function for two reasons: first, the first age when an individual claims OA benefits will decide whether he gets his full Primary Insurance Amount (PIA) or reduced PIA by actuarial adjustment factor or increased PIA through delayed retirement credit; second, earning tests for OA benefits are age specific. *Wage* earnings affect AIME computation, DI eligibility, and the earnings test for OA benefits.

Following Benítez-Silva, Buchinsky and Rust (2003), we approximate the evolution of the annual average wage, aw ($aw = \text{AIME} * 12$) at age t using aw at age $t-1$, annual earnings y at age $t-1$, and age t .

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

Given the above parameter estimates, the annual average wage aw at age t can be predicted as

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

Annual earnings y is then estimated using the predicted aw sequence in a log-normal regression model.

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

The estimated annual earnings are for full-time workers and part-time workers annual earnings are pro-rated accordingly.

The DI award probability $p_1(\text{wage}, h)$ is a function of wage and health status. If wage while applying is higher than the SGA level, the award probability becomes zero. Being in worse health status has a higher chance to be accepted to DI program.

An audit probability for DI recipients is denoted by $p_2(h)$. It is the probability of being audited by periodic reviews and being terminated from the DI roll due to health improvements. The audit probability depends on health status. Worse health has lower probability to be audited.

Social Security state variables. The Social Security state variable ss_t takes ten values: $ss_t=0$ denoting not on Social Security program, $ss_t=62, 63, \dots, 70$ denoting nine ages first entitled to OA benefits. Two variables, *age* and ss_t , are used together to define the state being

on DI program: $ss_t = \text{NRA}$ and $\text{age} < \text{NRA}$, denoting receiving full PIA at an age younger than NRA. We are allowed to do so because DI benefits are computed using the same formula as OA benefits and DI recipients can receive around 100 percent PIA before their NRA while OA beneficiaries can receive 100 percent PIA only when they reach their NRA.¹² 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.

Tax function $\tau(y_t, w_t)$. We include in our model the Social Security payroll tax, Medicare tax and progressive federal income tax (the negative tax indicates the Earned Income Tax Credit, or EITC). Federal income taxes are also imposed on 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:

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

The stigma function is equal to zero if one does not apply for DI benefits. $\phi(\text{age}, h_t, aw_t)$ is defined as disutility from work, which increases in age, decreases in average wage, and increases as health gets worse. Health affects utility both directly and indirectly through its effect on disutility from work. We assume that a stigma from applying for DI benefits exists and it increases in wealth and decreases in age.¹³

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

Based on our model, we'd like to discuss a bit the interactions between the DI and OA program incentives for ages between ERA and NRA.¹⁴

On the one hand, a DI applicant between age 62 to NRA has usually accumulated at least 40 quarters of coverage to be eligible for both DI and OA benefits, and he has already dropped out of labor force or retired due to disabilities. Especially considering that early retirement

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.

¹³ There has not any formal analysis to test whether stigma effect exists for DI applicants. Here we include a stigma function in the model to specify some unobserved factors that may explain why some people do not apply for DI benefits.

¹⁴ Leonasio, Vaughan, and Wixon (2003) had great description about the health and financial status of people aged 62-64 who received early Social Security retirement benefits.

benefits could provide insurance against possible DI benefit denial, a DI applicant will be probably better off claiming his early retirement benefit at the same time as DI applying. However, the tradeoff will be, once he claims early retirement benefit, his OA benefits could be “locked” at a lower level. If his DI application is denied, he will have to fall back on his retirement benefit which is at a reduced level almost permanently. So from a life-time perspective, an individual’s decision to apply OA or/and DI depends on the comparison of the present values of the expected life-time benefit flows which account for benefit amounts in the future years and expected mortality risks, as modeled in our framework.

On the other hand, an early retirement benefit claimer will probably be better off applying for DI benefits at the same time as filing for retirement, given that he has had quarters of coverage that satisfy both programs’ requirements, and his DI benefits will be higher than his early retirement benefits. If his DI application is approved, he could enjoy a higher level of benefits possibly in the rest of his life (DI benefits will automatically convert to OA rolls at NRA). If his DI application is denied, he could just fall back on his retirement benefits. However, an individual may not be able to apply for DI and OA simultaneously (or will be rejected of DI benefits for sure) if 1) he continues to work after claiming retirement benefits and earns higher than SGA level, which disqualifies him from DI benefits, or 2) he does not stay out of the labor force for at least five months to demonstrate his disability to work as required by the DI program eligibility, or 3) his earned quarters of coverage does not satisfy the “recency” requirement of the DI program, or 4) his health does not qualify him for DI benefits, or 5) he is deterred from applying by the relatively high uncertainty of getting approved, or 6) the stigma is relatively high for him to apply to DI program. Another important reason that is not modeled here is the lack of knowledge about the possibility of applying for DI and early OA benefits at the same time between ERA and NRA.

Although our model does not explicitly have a separate choice variable of applying for DI and OA benefits simultaneously, the model allows people who are on the OA roll to apply for DI benefits, and allows DI applicants and beneficiaries to claim OA benefits.¹⁵ It provides a theoretical prediction of people’s optimal decision making to apply for Social Security

¹⁵ For DI beneficiaries, claiming OA benefits is a choice in principle but rarely an optimal one because of the higher disability benefits than retirement benefits.

programs assuming that they have full information on the Social Security rules especially the rule on the simultaneous filing.

2.2. Solving the Model:

The value function in period t is the sum of current utility and the expected present value of utility from period t onward:

$$V_t(S_t) = \max_{D_t} \{u_t(S_t) + \beta * E_t V_{t+1}(S_{t+1} | S_t, D_t)\} \quad (5)$$

if one is alive at period $t+1$; or

$$V_t(S_t) = \max_{D_t} \{u_t(S_t) + \beta * EB(S_{t+1} | S_t, D_t)\} \quad (6)$$

if one dies at period $t+1$, where EB is the expected present value of bequest. In the Markovian stochastic decision problem described in (5) and (6), the vector of state variable S_{t+1} represents the state at the beginning of period $t+1$ and it depends on the state in the previous period S_t and the decision D_t made in the previous period. The vector of state variables $S_t = \{w_t, aw_t, ss_t, h_t\}$ includes wealth, annual average wage, Social Security state (being on OA or DI program) and health status. The vector of decisions (choice variables) $D_t = \{c_t, l_t, ssd_t\}$ includes decisions on consumption, labor supply and Social Security OA/DI application. β is the discount factor. The expected conditional value function in equation (7)

$$E_t V_{t+1}(S_{t+1} | S_t, D_t) = \sum_{h_t=0}^2 k_t(h_t | h_{t-1}) \int_{y_t} f_t(y_t | aw_{t-1}) \int V_{t+1}(S_{t+1}) * P_{t+1}(S_{t+1} | S_t, D_t) dy_t \quad (7)$$

where $P_{t+1}(S_{t+1} | S_t, D_t)$ represents the transition probabilities between Social Security states. This controlled stochastic process is subject to uncertainties from health transition $k_t(h_t | h_{t-1})$ and wage earnings $f_t(y_t | aw_{t-1})$.

The law of motion of one of the state variables, wealth w , is characterized as follows:

$$w_{t+1} = R * (w_t + y_t + ssb_t(aw_t, y_t) * I_t(ss_t > 0) - c_t - \tau(y_t, w_t)) \quad (8)$$

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

We solve the Markov stochastic decision problem expressed in (7) and (8) via numerical computation of the Bellman recursion for V_t since there is hardly any analytical solution to it. The optimal decision rule can be stated as follows:

$$D_t^*(S_t) = \arg \max_{D_t} V_t(S_t) \quad (9)$$

To compute the conditional expectation of the value function expressed in equation (9), we apply Gaussian quadrature algorithm to approximate the integral.¹⁶

At each period the optimization in (9) is performed over the (w, aw) state space. Wealth w is discretized into 15 grid points and average wage aw 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 value function's value will not always fall in the predefined grid points. We use two-dimensional simplicial interpolation algorithm to find the value for the value function at the nearest grid point as an approximation of the true value.¹⁷ 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, 10 Social Security states, 3 health states and the 80 periods. The procedure is repeated until the solution of the first period problem is obtained.

3. Data and Calibration

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

¹⁶ For a detailed discussion of quadrature methods, refer to Rust (1996) and Judd (1998).

¹⁷ Refer to Algorithm 6.5 by Judd (1998) pp. 243.

The HRS is a longitudinal study that follows persons aged 51-61 in 1992 and their households. The HRS provides rich information on respondents' demographics, health status, employment, income, wealth, and Social Security programs participation. The restricted data on earning histories of HRS cohorts are used to estimate the AIME, the base used to calculate the Primary Insurance Amount (PIA) that Social Security beneficiaries receive.¹⁸

Self-reported work limitations in the HRS data set are used to define the three disability statuses (good health, partially disabled, and fully disabled) in the model: 1) "Do you have any impairment or health problem that limits the kind or amount of paid work you can do?"; 2) "Does this limitation keep you from working altogether?" Individuals who answered *no* to the first question are defined as being in *good* health. Defined as being *partially disabled* are those who answered *yes* to the first question and *no* to the second question. That is, the partially disabled are those who self-reported to have work limitations that do not keep them from work completely though. The *fully disabled* are those who reported work limitations that keep them from work completely (who answered *yes* to both questions). One's health transitions between the three health statuses. One issue is that the health transition matrix estimated using data from the HRS is not age-specific but the average health transition probabilities. As far as I know, there is currently no available data that allows estimation of age-specific disability transition probabilities for younger ages according to the partial/full work disability definitions specified above. It is therefore very likely that the disability probabilities for younger ages have been overestimated (estimated from those of the HRS cohorts) due to the fact that younger ages likely have lower probabilities to develop disabilities than older ages. Then the DI application and award rates for younger ages have probably also been overestimated.

Mortality risk in the model is exogenously determined and is comparable to the death rate in the United States Life Table.¹⁹ The survival probabilities are first estimated from the HRS data for ages above 50. Then we use the survival probabilities from the U.S. Life Table for both older ages and younger ages, adjust it in an ad hoc way according to health status and indexed it off from the basic survival probability in the Life Table. To be consistent, we just use the health

¹⁸ 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.

¹⁹ The survival probabilities are taken from the U.S. Life Table, *National Vital Statistics Report*, vol. 54, no. 14, 2006, produced by U.S. Center for Disease Control.

adjusted survival probabilities based on the Life Table for all the ages. The weighted total survival probability by health distribution at each age for age above 50 estimated from the HRS data is very similar to that in the Life Table.^{20 21}

Following previous literature, the discount factor β takes value 0.96, and the constant relative risk aversion parameter $(1-\gamma)$ is 1.37. The health transition matrix is estimated from the HRS data ($k_{11}=0.95$, $k_{12}=0.04$, $k_{13}=0.01$; $k_{21}=0.25$, $k_{22}=0.68$, $k_{23}=0.07$; $k_{31}=0.05$, $k_{32}=0.10$, $k_{33}=0.85$). The DI award probabilities for the three health status (from better to worse) are estimated from the HRS data, and they are 0.62, 0.52, and 0.42, respectively. Estimated from the HRS data are also the DI audit probabilities for the three health status, 0.01, 0.02, and 0.05, respectively.

A form of the stigma function $stigma(w_t, age_t)$ in the utility function is chosen to help simulation results better match the observed age profile of DI entitlement, DI rolls, average monthly DI benefits, and employment. Bequest is simply the wealth left when an individual dies. Parameters of incentives under current DI program and OA program (benchmark model) include the Substantial Gainful Activity (SGA) earnings level (\$980/month in 2009 for non-blind), DI waiting period (one year), Early Retirement Age (ERA, 62), Normal Retirement Age (NRA, 65), Maximum Retirement Age (MRA, 70), earnings test and earnings tax rate for retirees between ERA and NRA (\$12,960/year and 0.5), earnings test and earnings tax rate for retirees in year reaching NRA (\$34,440 and 0.33), maximum taxable Social Security earnings (\$97,500/year), Social Security tax rate, actuarial reduction factor on early retirement benefits, and delayed retirement credit.

The structural model was solved by backward induction and the numerical solution was used to simulate life cycle path for 5,000 artificial agents. Figure 1-6 illustrate the fit of the model to the age profile of key variables. Figure 1 compares the simulated age profile of percentage of DI beneficiaries with the actual age 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

²⁰ Reliability of current mortality rate and assumption of future mortality projection are critical to make sound policy planning and prediction. The model in the paper could be improved by relaxing the assumption that mortality risks are exogenously determined.

²¹ My experiments show that using health adjusted age-specific survival probabilities or only age-specific survival probabilities do not really affect the model results. De Nardi, French and Jones (2006, page 32-33) also draw similar conclusions.

45-49 and 50-54 and less than 4 percent underestimation for those aged 60-64. Figure 1 illustrates the *stock* of the DI beneficiaries, the proportion of survivors at each age receiving DI benefits. In Figure 2, we see the age distribution of the *flow* of DI recipients, that is, the age distribution of all the new awardees. The flow of DI rolls illustrated in Figure 2 shows an overestimation for age 40-44 and age 45-49, and an underestimation for age older than 50-54, which represents a similar pattern as in Figure 1, except that the over-estimation appears a bit earlier in the *flow* (Figure 2) than in the *stock* (Figure 1). Despite some discrepancies between simulation results and real data, the model captures the general age pattern of DI entitlement reasonably well.

The above discrepancies between the simulated and the actual age profile of DI beneficiaries is very likely due to the fact that the disability transition matrix used in the model are age-constant and was estimated from the HRS data set, a relatively older sample of general population, while younger ages probably have lower probabilities to develop disabilities than older ages. Moreover, in the model the DI award probability is an increasing function in health (higher values of health denotes worse health and worse health has higher chance to get awarded), and the audit probability is a decreasing function in health (worse health has lower chance to be audited and removed), it is likely that we have overestimated the award probability and underestimated the audit probability for the younger ages due to the age-constant disability transition matrix. That could possibly help explain part of the overestimation of percentage of DI recipients among the young ages.²²

In Figure 3 and Figure 4, the model reproduces the age profile of average monthly DI benefits. The average monthly benefits are a function of the AIME which is a summary of one's earnings history. The model predicts the age profile of average monthly DI benefits quite well, implying a relatively well-predicted age profile of earnings histories. Figure 3 illustrates the benefits of the *stock* of DI beneficiaries, while Figure 4 shows the benefits of the *flow* of DI recipients. Both figures have captured the general pattern of increasing monthly benefits with age although there are some discrepancies in the slope of age profile of benefits.

²² We tried the simulation with some artificial age-specific disability transition probabilities (smaller probabilities for younger ages and larger probabilities for older ages) and the results did seem to better match the actual age profile of DI entitlement.

Those discrepancies are mostly due to the way we estimate the annual earnings and the way we approximate the average wage (aw). 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 earnings levels than current general population. Therefore the annual earnings estimated from HRS cohorts' earning histories are likely to be lower than that of actual population. Figure 5 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 age 55-64 are understated by about 2,200 dollars. This may be part of the reason that the simulated average monthly DI benefits are underestimated for the older recipients.

Figure 6 illustrates the age profile of employment rate. The general employment pattern predicted by the model matches the actual data 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. Part of the reason for this discrepancy could be that unemployment risk and lay-off risk are not considered in the model and therefore employment rate has been overestimated.

4. Simulation Results and Discussion

In our life-cycle structural model, we change the value of DI policy variables, such as the DI benefit amounts and the DI award probability and simulate the effect of those changes on DI application decisions. According to the simulated DI application rates, we are able to calculate the elasticity of DI application with respect to the benefit amount and the award probability. The calculated elasticities are presented in Table 1 and Table 2. The age group of our main interest is 62-NRA. This study takes advantage of this special age window, separates out the effect of Medicare coverage provided by the DI program on application behavior, and therefore more accurately measures the effect of cash benefit incentives on DI application decisions. For comparison purpose, the younger age group 21-61 and also the age groups used in the previous literatures are examined.

Our estimated benefit elasticity (and award probability elasticity) at age 62-NRA is much higher than that at younger ages, for example, age 21-61, as shown in Table 1 (and Table 2). In

other words, individuals at age 62-NRA are more responsive to DI benefit changes (and the award probability changes) than younger individuals when they are making decisions to apply to the DI program. Since Medicare incentives do not have much effect for this age range, the financial incentive dominates in one's decision to apply to DI program. At this age range, OA benefits become available and create "competing" financial incentives with DI benefits, as discussed in detail earlier in the Model Section. DI benefits are around 100% of one's Primary Insurance Amount. When DI benefits decrease by 20% or 40% (or when the DI approval probability decreases), OA benefits, even though at reduced level (20% of the full Primary Insurance Amount at age 62 for most cohorts in our model), will look more attractive in comparison, especially considering there is also uncertainty of getting DI benefits after applying.²³ However, claiming early retirement benefits has the risk of "locking" the retirement benefits at a reduced level possibly permanently.²⁴ ²⁵ So from a life time perspective, an individual's decision to apply OA or/and DI depends on the comparison of the present values of the expected life-time benefit flows which account for benefit amounts in the future years and expected mortality risks, as modeled in our framework.

For a Social Security covered individual with certain earnings history, his DI benefits are usually higher than his early retirement benefits. DI benefits can become even more appealing than OA benefits when the former are raised by 20% or 40% (or when the DI approval probability increases). However, the decision to apply also accounts for the rejection risk from DI program, the work restriction and the audit risk once on the DI program, as characterized in our structural model. In short, as in the model, the decision is made after an individual compares the present values of expected life-time benefits flows which account for Social Security benefits, work earnings, all the uncertainties (health transitions, survival probabilities, DI rejection risks for applicants and audit risks for beneficiaries, earning fluctuations), and other

²³ A DI applicant who has accumulated the required quarters of coverage at age 62 or over will most probably satisfy the quarters of coverage requirement of OA program. The DI eligibility requires 40 Social Security credits for age 62 or over and unless the applicant is blind, at least 10 of the credits must have been earned in the 10 years immediately before the onset of disability. The OA eligibility requires 40 Social Security credits for those born in 1929 or later such as HRS cohorts in our sample.

²⁴ Unless he continues to work and earns above certain amount to have his benefit recalculated later. Detailed discussion in this aspect could be found in Benitez-Silva and Heiland (2008) and Manchester and Song (2007).

²⁵ We are currently calculating the elasticity of DI application with respect to the ratio of DI benefits over OA benefits to control for the confounding effect of OA benefits. In Duggan, Singleton, and Song (2007), they found a modest effect of increases in NRA, therefore the ratio of DI benefits to OA benefits, on DI application.

factors. In the simulation, we do observe an increase in DI application propensity after the benefits rise (or the approval probability increase).

In comparison, younger individuals' DI application decisions are less responsive to benefits amount changes (and the award probability changes). One reason is that they do not have a comparable benefit option such as OA benefits as the age between 62 to NRA group has, which makes their DI application decisions less elastic to any change in the DI policy variables. The other reason that DI application decisions are less elastic among younger people is that besides cash benefits, Medicare coverage is another important benefit they are after when deciding to apply to the DI program. The effect on DI application of any change in cash benefits alone can be diminished by the effect of Medicare incentives. For example, a cash benefit cut will probably not have as big an impact on DI applications as when individuals take into account the value of the Medicare coverage provided by the DI program. The benefit elasticity shown in Table 1 is generally lower among younger ages (below age 62) than among near retirement ages (between 62 to NRA). The benefit elasticity estimated in our model that does not yet characterize the Medicare incentive (we will discuss the limitation of our model shortly) is conjectured to be lower when the Medicare incentives are properly modeled.

One issue with our model is that we do not yet model the Medicare coverage provided by the DI program. As mentioned earlier, Medicare is an important in-kind benefit for disabled individuals. People younger than age 62 apply to DI program for not only cash benefits but also Medicare coverage. Our current estimates of the cash benefit elasticity for younger ages (below age 62) are likely overstated due to the limitation of the model without modeling Medicare benefits. We conjecture that once we include Medicare in the model, the benefit elasticity of DI application for younger ages (age 21-61 and other younger age groups) we estimate in this study will probably be lower. That is, individuals' DI application decisions will be less sensitive to changes in cash benefits alone when they take into account the Medicare coverage benefit offered by the DI program. Especially when the DI benefit drops, we would speculate that disabled individuals would less likely change their minds to apply to DI program considering the value of Medicare coverage. For example, in Table 1, for people before reaching their NRA (those at age 21-NRA, which is age group 21-61 plus age group 62-NRA, a mixed pool of possible applicants who should be affected by Medicare incentives and who should not be affected, and the pool is dominated by the former), our estimated benefit elasticity when

benefits drop by 20% or 40% (1.847 and 2.181) is more than three times the estimate by Lahiri, Song and Wixon (2008) who predict expected Medicare values for a sample aged 18-64 in their model while estimating the elasticity of DI applications.²⁶

Next we discuss some other interesting results found in the study.

Comparing the results in Table 1 and Table 2, in general the DI award probability elasticity is higher than the DI benefit elasticity. That is, people are more responsive to the changes in the approval probability than the changes in benefit amounts. It is consistent with the results of Lahiri, Song and Wixon (2008).

In Table 1, unlike the elasticity estimate based on an average application probability in previous literature that conducted simulation in a reduced-form model,²⁷ the responses are not symmetric to benefit increases and reductions of equal amounts. It is also true for the award probability elasticity estimates in Table 2. For example, at age 62-NRA, the responsiveness to 40% increase in benefit amounts (1.959) is only half of that to 20% benefit increase (3.946). At age 45-59, the elasticity (1.193) when benefit amounts drop by 40% is more than half of that (0.513) when benefit amounts drop by 20%, that is, more than 40% of individuals at this age range will choose not to apply to DI program when benefits drop by 40%, while only about 10% of individuals will choose not to apply when benefits drop by 20%.

We also find some interesting dynamic effects in our life cycle structural framework. What seems unusual in our estimates results are the benefit elasticity at age 45-59 and age 50-61 when benefits drop by 40%, -0.264 and -0.494, respectively. It seems puzzling: when benefits increase, why would DI applications decrease? This has to do with us putting the research question in a life cycle framework. As illustrated in Figure 7, when DI benefits increase by 40%, a lot more individuals choose to apply at younger ages. So when we look at the older age groups, for example, age 45-59 or age 50-61, we see fewer DI applicants than in the benchmark model, that is, before the benefits rise. This effect can be analyzed only in a life cycle structural model.

²⁶ Once Medicare is included into the model, the incentives to apply for DI benefits at younger ages (than 62) would be stronger, and the sensitivity of DI application propensity to policy changes at older ages would probably be smaller.

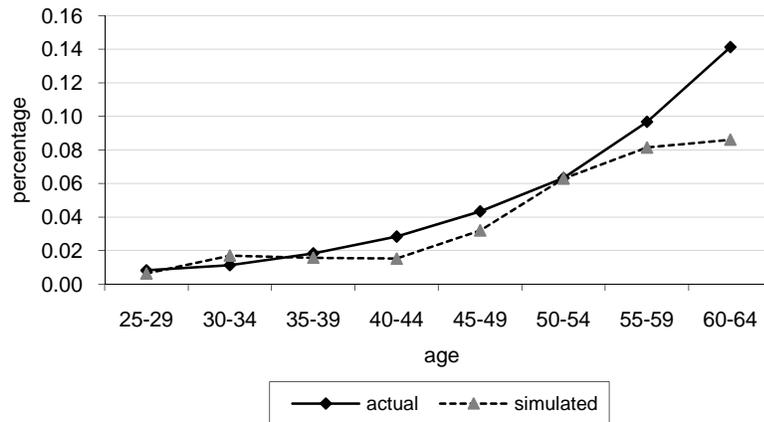
²⁷ Halpern and Hausman (1986) estimate a benefit elasticity of 1.3 using a 1972 male sample younger than age 50. Kreider (1998) estimates a benefit elasticity of 0.7 using a 1978 sample at age 45-59. Kreider and Riphahn (2000) estimate a benefit elasticity of 0.51 for men and 0.75 for women using a 1992 sample at age 50-61. Lahiri, Song and Wixon (2008) estimate a benefit elasticity of 0.5 for men using a 1990-92 sample at age 18-64.

A simulation on a reduced-form model could provide a short-run elasticity estimate but will probably average out such dynamic effect as the changing age structure of applicants and the application timing shift when there are changes in policy variables. Similar dynamic effects are also seen in Figure 8-10. In Figure 8, when DI benefits are cut, there are bigger drops in DI applications among younger people, and some of them postpone their DI application decisions. So we see that the decreases in DI applications at later ages are not as dramatic as at younger ages, and we even see an increase in DI applications at age 56-58. Figure 9 and 10 illustrate similar dynamic effects when the DI approval probability changes.

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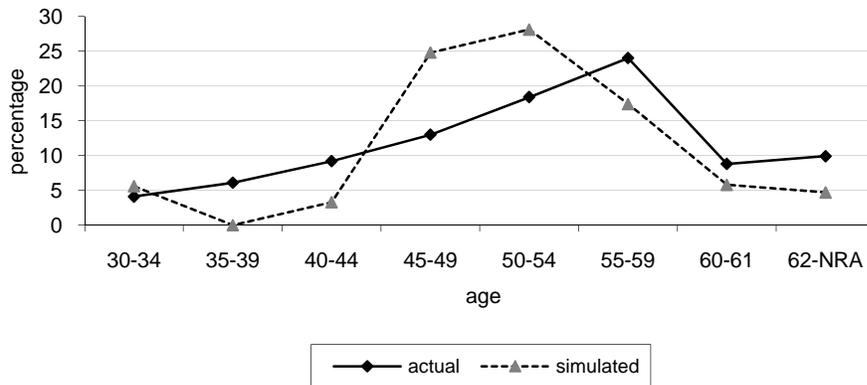
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Figure 1: Percentage of DI worker-beneficiaries by age



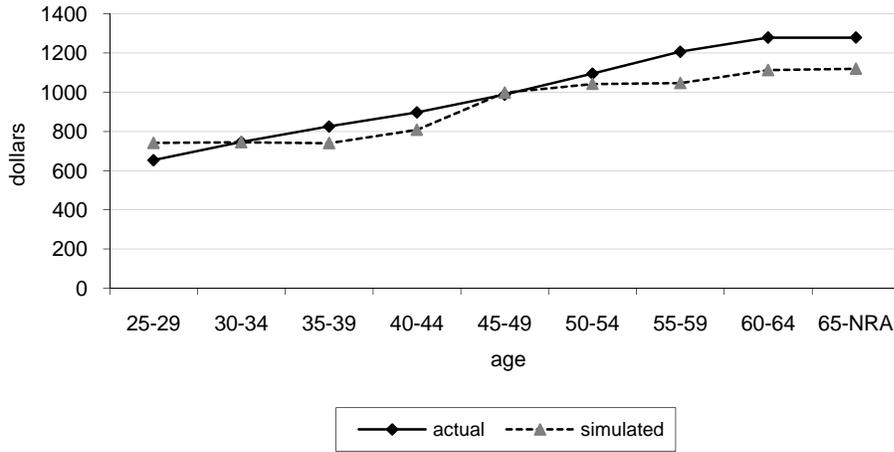
Note: The actual percentage is author's calculation based on population estimated produced by US Census Bureau and Table 4 of Annual Statistical Report on the DI program, 2006. We cannot calculate the actual award rate for age 65-66 since we don't have the statistics for population at that age range.

Figure 2: age distribution of DI awardees



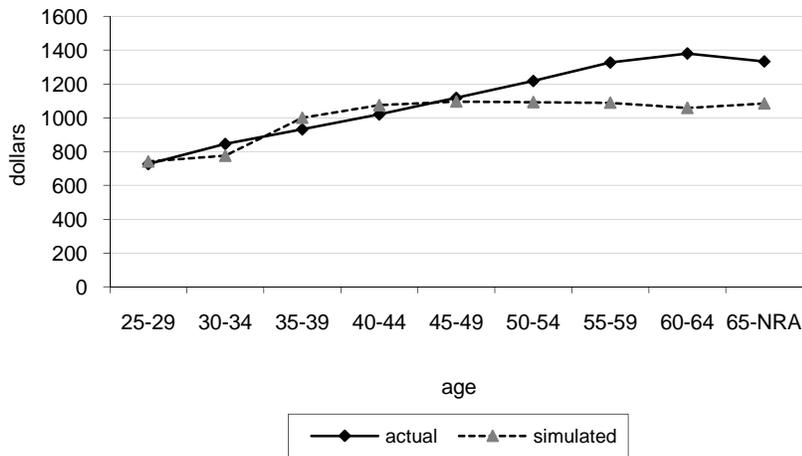
Note: The actual statistics are from Table 39 of *Annual Statistical Report on the DI program, 2006*. We include only disabled workers. Their dependents are not included in the calculation.

Figure 3: average monthly DI benefits by age



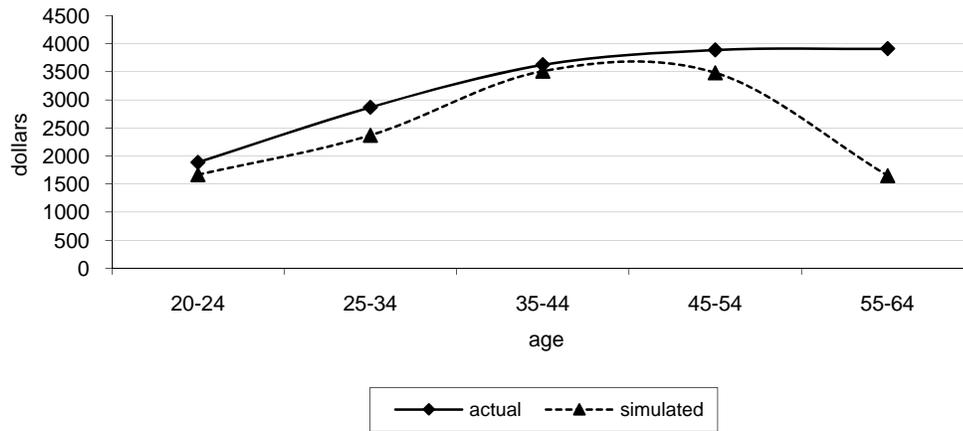
Note: The actual statistics are from Table 4 of Annual Statistical Report on the DI program, 2006. We include only disabled workers. Their dependents are not included in the calculation.

Figure 4: average monthly DI benefits, by basis of entitlement and age



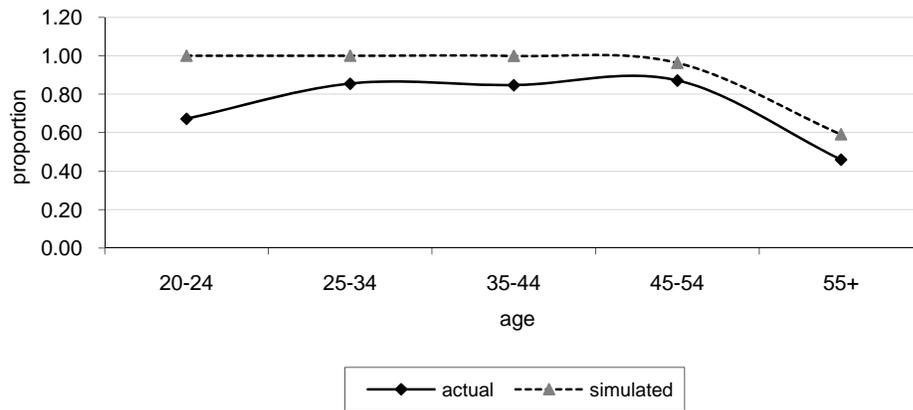
Note: The actual statistics are from Table 36 of Annual Statistical Report on the DI program, 2006. Benefits are in 2006 dollars. NRA=Normal Retirement Age.

Figure 5: Median monthly wage for FT workers



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 6: 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.

Table 1: Benefit Elasticity of DI Application

Change in DI Benefits					
Amount	-40%	-20%	Benchmark	20%	40%
Age 62-NRA	3.201	2.912		3.946	1.959
Age 21-61	2.180	1.856		0.353	0.299
<i>Age ranges used in previous literature</i>					
Age 21-50 ^a	3.707	2.755		0.481	0.622
Age 45-59 ^b	1.193	0.513		0.073	-0.264
Age 50-61 ^c	0.391	0.358		0.101	-0.494
Age 21-NRA ^d	2.181	1.847		0.362	0.306

a. Halpern and Hausman (1986) estimate a benefit elasticity of 1.3 using a 1972 male sample younger than age 50.

b. Kreider (1998) estimates a benefit elasticity of 0.7 using a 1978 sample at age 45-59.

c. Kreider and Riphahn (2000) estimate a benefit elasticity of 0.51 for men and 0.75 for women using a 1992 sample at age 50-61.

d. Lahiri, Song and Wixon (2008) estimate a benefit elasticity of 0.5 for men using a 1990-92 sample at age 18-64.

Table 2: Award Probability Elasticity of DI Application

Change in DI Award Prob.	-40%	-20%	Benchmark	20%	40%
Age 62-NRA	5.000	8.026		6.811	3.750
Age 21-61	3.796	3.397		1.551	1.312
<i>Age ranges used in previous literature</i>					
Age 21-50 ^a	4.579	4.873		1.620	1.356
Age 45-59 ^b	3.520	2.220		1.117	0.768
Age 50-61 ^c	2.776	1.247		1.368	1.150
Age 21-NRA ^d	3.798	3.402		1.584	1.329

a. Halpern and Hausman (1986) estimate an award prob. elasticity of 0.2 using a 1972 male sample younger than age 50.

b. Kreider (1998) estimates an award prob. elasticity of 0.6 using a 1978 sample at age 45-59.

c. Kreider and Riphahn (2000) estimate an award prob. elasticity of 0.67 for men and 0.26 for women using a 1992 sample at age 50-61.

d. Lahiri, Song and Wixon (2008) estimate an award prob. elasticity of 1.64 for men and 1.43 for women using a 1990-92 sample at age 18-64.

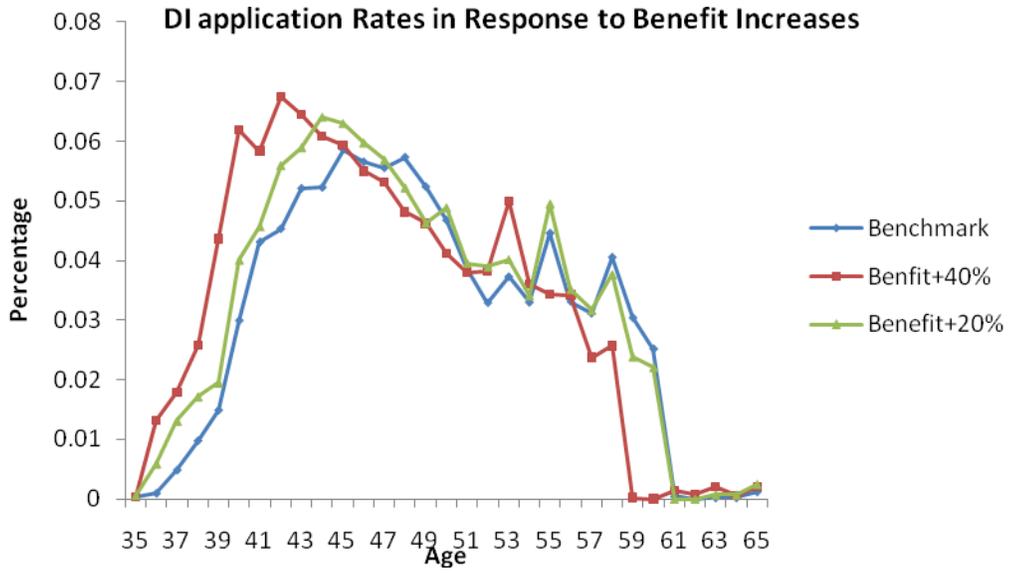


Figure 7

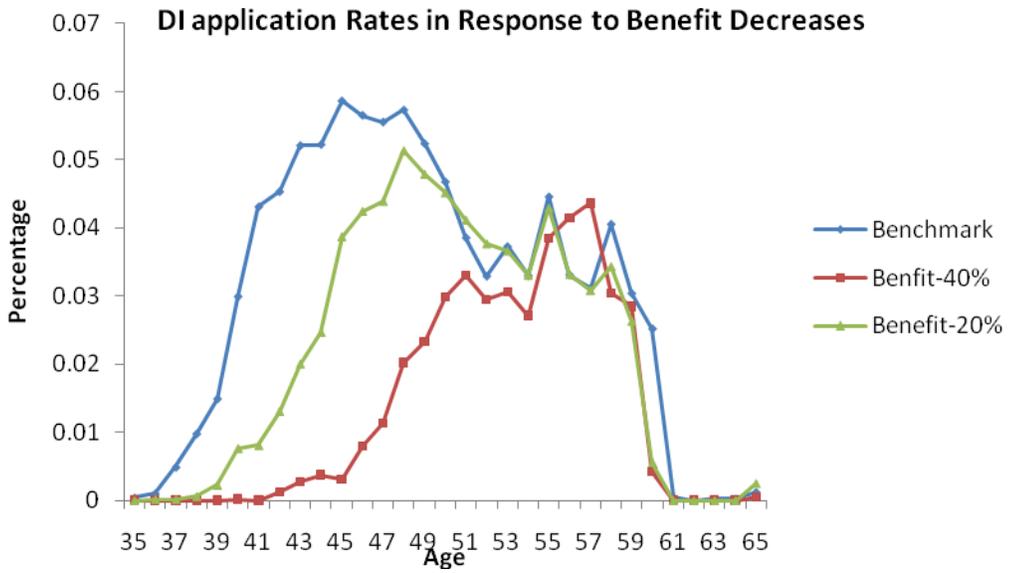


Figure 8

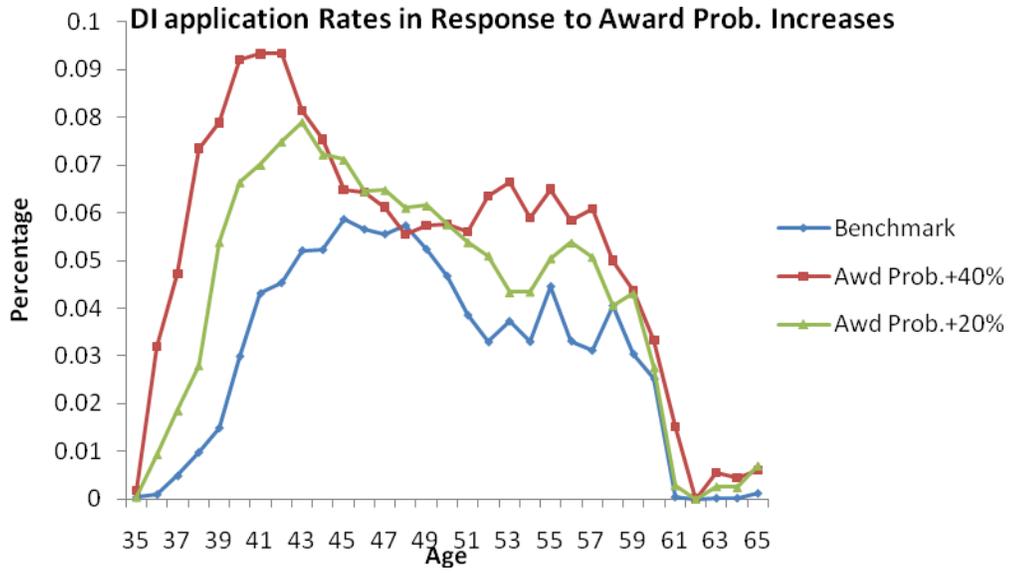


Figure 9

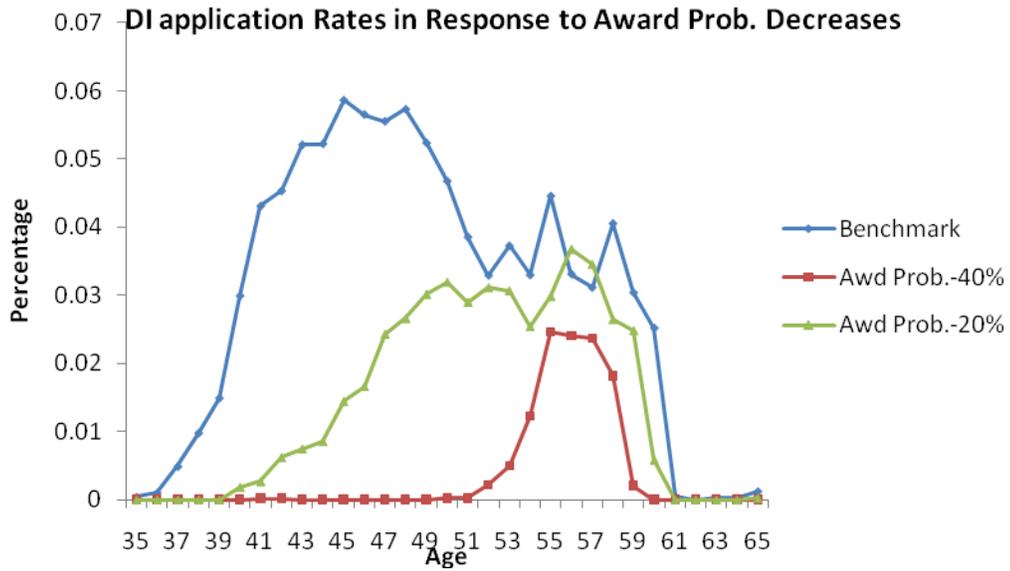


Figure 10