A Unified Framework to Evaluate Social Security Old-Age Insurance and Disability Insurance Reforms

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Abstract

This paper designs a life-cycle model with search friction and social security claiming choices, which captures increases in disability insurance (DI) claims resulting from decreased old-age insurance benefits. The model finds that raising the normal retirement age from 66 to 67 reduces long-term labor supply by 0.4 percent and increases DI spending by 44.2 percent. The comparison between two alternative DI reforms suggests that a small benefit decrease for all is preferred to a large benefit decrease for the elderly. This is because the formal reform encourages youth employment and skill accumulation, while the latter reform has the opposite effect.

JEL: E21, E24, E62, H55, J68.

Keywords: Social Security, Government Budget, Labor Supply

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1 Introduction

In the past, decreasing old-age insurance (OAI) benefits is used as a policy tool to reduce social security expenses and raise elderly labor supply. However, the literature (Duggan et al., 2007; Li and Maestas, 2008; Coe and Haverstick, 2010) has identified a side effect of such policy: in response to decreased OAI benefits, more people file disability insurance (DI) claims and become DI recipients. After considering rising DI enrollments, it is not clear that a decrease in OAI benefits will always achieve its policy goals, because the induced DI recipients are likely to exit the labor force at an earlier age and receive more social security benefits over the life course. To capture the side effect of OAI reforms, this paper designs a life-cycle model with search friction and social security claiming choices, including both DI and OAI claims. The model is used to predict the long-term influence of a set of social security reforms, including the scheduled future OAI reform that increases the normal retirement age (NRA) from 66 to 67.

The existing literature (Gustman and Steinmeier, 1985; Imrohoroğlu and Kitao, 2012) studying OAI reforms concludes that decreased OAI benefits raise labor supply via the income channel. This paper extends the literature by considering three new channels that work against the income channel. First, decreased OAI benefits induce more people to stop working and file DI applications. Second, following DI screening decisions, the new applicants who are awarded benefits permanently leave the labor force, and those who are denied benefits may suffer from skill depreciation and have a small likelihood to regain employment (Autor et al., 2015; French and Song, 2014). Third, perceiving the greater probability of exiting the labor force as a DI recipient reduces young people's incentive to accumulate skills and hence their attachment to the labor force when they age. Since there are two opposing forces, whether decreased OAI benefits will encourage labor supply is an open question that needs to be answered by a structural model.

The model developed below introduces social security claiming decisions to a search framework. Each period, individual who are not currently employed or on the social security rolls can choose whether to file a DI claim at an age dependent utility cost. DI applicants may receive DI benefits and exit the labor force permanently according to a health-dependent probability. Rejected DI applicants may experience skill depreciation due to the prolonged employment gap, and hence are very likely to continue filing DI claims rather than searching for jobs. The model allows individuals who are not yet on the social security rolls to pick up an age between 62 and 70 to file an OAI claim. This design has two merits. First, it permits individuals to retire and wait for the optimal time to file an OAI claim. Second, it permits the model to distinguish OAI early retirement penalties from OAI delayed retirement credits, which is important, because in the past, the Social Security Administration has independently adjusted early retirement penalties and delayed retirement credits. In the model, social security reforms affect search intensity, which in turn, determines the economy's skill distribution.

The model is calibrated to match the 2010 US economy. In addition to the targeted moments, the model closely matches the data life-cycle profiles of employment and DI recipients. To compare the model predicted increase in DI recipients resulting from reduced OAI benefits with the literature estimate, the model constructs a counterfactual economy which imposes the OAI benefit rules for the 1937 birth cohort. The comparison between the new economy and the benchmark economy indicates that the past OAI reform (the change from 1937 to 1943-54 birth cohorts) raises the percentage of people aged 45-64 on the DI rolls by

0.5 percentage points, which is very close to the estimate of 0.6 percentage points in Duggan et al. (2007). In addition, consistent with the results in Pingle (2006), Mastrobuoni (2009), and Blau and Goodstein (2010), the model finds that the past OAI reform raises labor force participation and employment.

The model suggests that the future OAI reform (the change from 1943-54 to 1960 and later birth cohorts) that raises the NRA from 66 to 67 leads to a 0.4 percent reduction in labor supply and a 44.2 percent increase in DI spending.[1] With the NRA fixed at 67, the paper compares two alternative DI reforms which both reduces DI spending to a level that is similar to the current spending. The first reform is a plan that has been examined by the CBO and that intends to reduce DI benefits for new elderly recipients. The second reform plans to reduce DI benefits for new recipients of all ages. The model finds that the first reform induces more young and middle-aged individuals to withdraw from the labor force and file DI claims. Under the first reform, the number of DI applicants aged 20-59 rises by 2.3 percent. By contrast, the second reform substantially discourages young and middle-aged people to file a DI claim. Under this reform, the number of DI applicants aged 20-59 drops by 39.7 percent. Due to the positive impact on young and middle-aged individuals, the second reform economy has greater ex-ante utility than the first reform economy.

This paper is related to three strands of literature. The first strand of literature develops models to simulate the influence of social security reforms (Gustman and Steinmeier, 1985; Mitchell and Phillips, 2000; Bound et al., 2010; Imrohoroğlu and Kitao, 2012). In this literature, Mitchell and Phillips (2000) and Bound et al. (2010) also consider the rising DI claims resulting from decreased OAI benefits, but their models abstract from consumption-

[1] 31 percent of the extra DI spending is used for paying benefits to people aged 66, who stay on the DI rolls for an additional year after the rise of the NRA.

saving decisions and early-life responses, and predict that the decrease in OAI benefits only slightly raises DI claims. With less restricted assumptions, my model is able to generate an increase in DI enrollments that is near the estimate of Duggan et al. (2007). The second strand of literature studies labor force participation along the life-cycle (Rust and Phelan, 1997; French, 2005; Cutler et al., 2007; Rogerson and Wallenius, 2009a,b; French and Jones, 2011; Low et al., 2010; Kitao, 2014; Li, 2014). Extending this literature, my paper studies the incentive of taking DI as a pathway for early retirement and the impacts on employment dynamics. The model is close to that of Kitao (2014), but differ from hers by adding the decision of filing OAI claims. The last strand of literature discusses potential ways to reform DI (Golosov and Tsyvinski, 2006; Autor and Duggan, 2010; Burkhauser and Daly, 2011; Low and Pistaferri, 2012; Kitao, 2014; French and Song, 2014). Related to the discussion, this paper develops a model that is suitable to quantitatively assess social security reforms.

The reminder of the paper is organized as follows: section 2 describes the incentive to claim DI; section 3 presents the model; section 4 explains the calibration; section 5 evaluates the model; section 6 simulates social security reforms; section 7 discusses model's assumptions; and section 8 concludes.

2 Incentive to File DI Claims

Individuals on the margin of filing DI claims generally compare two alternative options: first, keep working and file an OAI claim after retirement; second, stop working, file a DI claim and exit the labor force permanently if awarded benefits. The attractiveness of the second option depends on four aspects: the cost of filing DI claims, the probability of passing DI screening, the generosity of DI benefits relative to wage earnings, and most importantly, the generosity of DI benefits relative to OAI benefits. In this paper, the first two aspects are fixed. The third aspect is endogenous to skill accumulation since the ratio of DI benefits to wage earnings drops as skill increases. The fourth aspect is a policy variable that is controlled by OAI reforms.

Under the current social security rules, all DI recipients receive their PIA regardless of the entitlement age and the birth cohort. But for OAI recipients, benefits are reduced according to an early retirement penalty if an OAI claim is filed earlier than the NRA, and are increased according to a delayed retirement credit if a claim is filed later than the NRA. The NRA varies by cohorts: it is 65 for 1937 and earlier birth cohorts, 66 for 1943-54 birth cohorts, and 67 for 1960 and later birth cohorts. The change in NRA was scheduled by the 1983 Social Security Amendments for the purpose of reducing social security expenses. In addition, the 1983 amendment also scheduled the increase of delayed retirement credits to 8 percent per year for the purpose of being actuarially fair.

Figure 1 compares the ratio of social security benefits to the Primary Insurance Amount (PIA) for DI recipients with the ratio for OAI recipients under different scenarios. The solid line displays the ratio of benefits to PIA for the 1943-54 birth cohorts who are currently around the retirement age. For them, the penalty for filing an OAI claim at age 62 is a 25 percent decrease in benefits, and the credit for filing an OAI claim at age 70 is a 32 percent increase in benefits. OAI becomes less generous over time. Comparing the 1937 birth cohort (the dashed line) with the 1960 birth cohort (solid line), the early retirement penalty at age 62 rises from 20 to 30 percent, and the delay retirement credits at age 70 drop from 32.5 to 24 percent. Since DI benefits remain unchanged but OAI benefits decrease, more and more

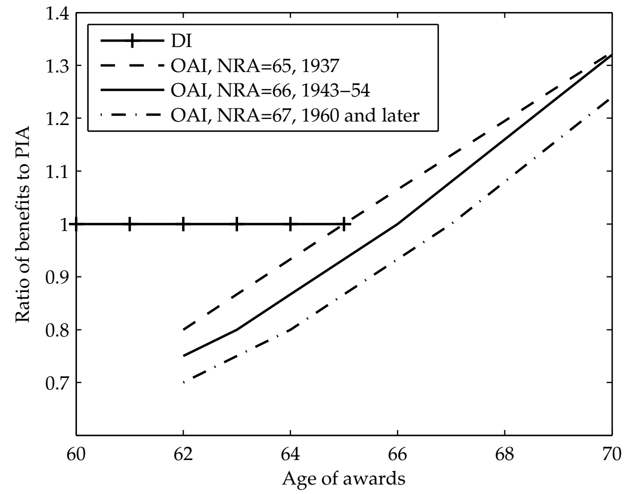


Figure 1: Social Security Benefits by Entitlement Age and Birth Cohort

individuals file DI claims. As will be discussed below, this paper utilizes the policy variation of the past OAI reform, that is, the change from the dashed line to the solid line, to evaluate the model; make predictions about the future OAI reform, that is, the change from the solid line to the dash-dot line.

3 Model

This section presents the model. To illustrate the main mechanisms, a simplified version of model is available in Appendix A.

3.1 Demographics

The economy consists of a continuum of individuals with stochastic life-spans. Let $j = 1, 2, \ldots, J$ index the age group. The probability of an individual transiting from age group j

to $j+1$ is denoted by ψ_j.[2] Between periods, individuals face mortality risks. Let $s_j(h)$ denote the probability of surviving to the next period, where h is the current health status. The survival rate drops as individuals age or health deteriorates. Assets of deceased individuals are redistributed equally among all alive individuals as a lump-sum transfer, the amount of which is denoted by x. Individuals are grouped into four categories: employed individuals (denoted by superscript e), DI recipients (denoted by superscript d), OAI recipients (denoted by superscript r), and other individuals (denoted by superscript o). Other individuals include both job seekers and people who are out of the labor force but have not yet moved onto the social security rolls.

3.2 Preferences

Individuals derive utility from consumption c and leisure l. The utility function $u(c, l)$ obeys Inada conditions. Future utility is discounted by a factor of β. Each period, individuals are endowed with one unit of time. Employment costs $N^e(h)$ units of time, and job search costs $N^u(h, v)$ units of time, where $v \in [0, 1]$ is search intensity. Bad health raises the time cost of employment and search. Time and monetary costs for DI applications are captured by a direct utility cost $u^d(j)$. In order to reflect that DI screening process is more lenient as people age, the model allows $u^d(j)$ to decline over the life cycle.

[2] This approach is built on an overlapping generations framework developed by Blanchard (1985) and Weil (1989). This framework is extended to allow for life-cycle behaviors by a number of papers, including Gertler (1999), Cagetti and De Nardi (2009), Ljungqvist and Sargent (2008), and Kitao (2014).

3.3 Labor Market

Employed individuals earn labor income wg, where w is the unit wage and $g \in [\underline{g}, \overline{g}]$ is the skill level. Employed individuals accumulate skills according to a Markov process with transitions $\gamma_j^e(g, g')$, where the subscript j denotes the age index. Job separation can be either voluntary or involuntary with an age dependent probability $\sigma(j)$. Skill levels depreciate during employment gaps according to a Markov process with transitions $\gamma_j^o(g, g')$. $\pi^u(v)$ ($\frac{\triangle \pi^u(v)}{\triangle v} > 0$) denotes the probability of receiving a job offer conditional on search. In the model, individuals control the duration of employment gap and skill accumulation by choosing job separation and search intensity.

3.4 Health, Medical Expenditures, and Health Insurance

Health status changes stochastically over the life cycle according to a Markov process with transitions $\gamma_j^h(h, h')$. Health status affects individuals through four aspects: survival probability, the time cost of employment and search, the probability of passing DI screening $\pi^d(h)$, and the distribution of medical expenses. Medical expenses $m(j, h, \epsilon)$ depend on age, health status, and a health spending shock ϵ. $\Pi(\epsilon)$ denotes the distribution of health shocks.

Individuals are covered by either private insurance ($i = 0$) or public insurance ($i = 1$), where i denotes the insurance status. Public insurance resembles the Medicare program that provides immediate coverage for individuals reaching the age of 65 (J^M), and delayed coverage for DI recipients. The model assumes that all DI recipients under the age of 65 are not eligible for public insurance unless they receive an insurance shock. The probability of insurance shock π^M is set to match the 2 year Medicare waiting period.

Individual health spending includes both out-of-pocket medical expenses and insurance premiums:

$$Q(m(j,h,\epsilon),i) = q_i m(j,h,\epsilon) + P_i,$$

where q_i is the coinsurance rate for insurance status i, and P_i is the corresponding insurance premium.

3.5 Government

The government collects taxes and operates OAI, DI, unemployment insurance, social insurance, and public insurance.

Old-Age Insurance: Let J^E, J^N, and J^L denote the Early Retirement Age (ERA), the NRA, and the Late Retirement Age (LRA). j^r denotes the age of filing an OAI claim. If a claim is filed at the NRA, an individual is entitled to receive her full PIA, denoted by $PIA(e)$, where e is an earning index summarizing the earning history. If a claim is filed at another age, OAI benefits $b^r(e, j^r)$ are adjusted according to pre-specified early retirement penalties and delayed retirement credits.

Disability Insurance: Individuals who are younger than the NRA and have been separated from jobs for at least one period, can file a DI claim. This one period requirement resembles the 5 month waiting period for DI eligibility. $i^d \in \{0, 1\}$ denotes DI application decision. DI applicants are awarded DI benefits with a health dependent probability $\pi^d(h)$, and are awarded OAI benefits if they reach the NRA. The benchmark economy sets DI benefits $b^d(e)$ to $PIA(e)$.

Unemployment Insurance: $b^u(e, d_u)$ denotes the amount of unemployment benefits, where d_u is the duration of unemployment. Unemployment benefits decline as unemployment duration rises and drops to zero if the duration of unemployment is longer that or equal to a period threshold $\overline{d^u}$. Individuals who have filed DI claims in the current employment gap are not eligible for unemployment benefits.

Social Insurance: Social insurance can be thought as a combination of Medicaid and other means-tested transfer programs. Social insurance provides a consumption floor of $\underline{c}$: $b^s = \max\{0, (1+\tau^c)\underline{c} - a\}$, where τ^c is the consumption tax rate and a is the amount of assets at the beginning of each period.

Taxes and Direct Spending: The government collects three types of taxes: labor taxes at a rate of τ^s, consumption taxes at a rate of τ^c, and capital taxes at a rate of τ^k. To balance the budget, the government directly spends an amount of G each period.

3.6 Individual Problem

An individual is characterized by her category and a category dependent state vector. The state vector for employment individuals, DI recipients, OAI recipients, and other individuals, are, respectively, $S^e = (j, a, g, h, e)$, $S^d = (j, a, h, b^d, i)$, $S^r = (j, a, h, b^r)$, and $S^o = (j, a, g, h, e, d_u)$. At the beginning of each period, individuals receive the social insurance transfer b^s and choose goods consumption $c \geq \underline{c}$. After deducting consumption expenses, individuals rent the remaining assets k to the market and earn interests at a rate of r. k has the following form:

$$k = \max\{a - (1+\tau^c)c, 0\}. \tag{1}$$

In addition to consumption, other individuals also determine whether to file a DI claim, and choose search intensity if decide not to file a claim. Individuals who pick up zero search intensity are defined as out of the labor force.

At the end of each period, individuals learn about health spending shocks and realizations of future state variables, including survival, age groups, heath status, skill levels, involuntary job separation (for employed individuals), DI awards (for DI applicants), arrivals of job offers (for individuals who search for jobs), and insurance shocks (for DI recipients). If individual health spending is greater than available resources, people carry negative assets $a' < 0$ and consume at the consumption floor for the next period. All individuals at and older than the ERA can file OAI claims and become OAI recipients. In addition, employed individuals can quit their jobs, and other individuals who receive a job offer can decide whether to accept it. Aging, receiving adverse health shocks, and incurring adverse skill shocks are the three main reasons that cause people to stop working. DI and OAI recipients are absorbing states, except that DI recipients are relabeled as OAI recipients once the NRA is reached. All individuals enroll into the OAI program once the LRA is reached.

Formally, given prices and taxes, the dynamic problem for the category of other individuals can be written as below. The dynamic programs for the rest three categories are available in appendix B.

Younger than NRA (eligible for DI):

$$V^o(j,a,g,h,e,d_u) = \max_{c,v,i^D}\{u(c,1-N^u(h,v)) - i^D u^d(j) + \beta s_j(h) E_{\epsilon,j',g',h'|j,g,h}$$

$$[i^D I_{j'=J^N} V^r(j',a',h',b^r(e',j')) + i^D \pi^d(h) I_{j'<J^N} V^d(j',a',h',b^d(e',j'),I_{j'\geq J^M})$$

$$+ i^D(1-\pi^d(h)) I_{j'<J^E} V^o(j',a',g',h',e',\overline{d^u})$$

$$+ i^D(1-\pi^d(h)) I_{J^E\leq j'<J^N} \max\{V^o(j',a',g',h',e',\overline{d^u}), V^r(j',a',h',b^r(e',j')\}$$

$$+ (1-i^D)\pi^u(v) I_{j'<J^E} \max\{V^e(j',a',g',h',e'), V^o(j',a',g',h',e',d_u+1)\}$$

$$+ (1-i^D)\pi^u(v) I_{j'\geq J^E} \max\{V^e(j',a',g',h',e'), V^o(j',a',g',h',e',d_u+1), V^r(j',a',h',b^r(e',j')\}$$

$$+ (1-i^D)(1-\pi^u(v)) I_{j'<J^E} V^o(j',a',g',h',e',d_u+1)$$

$$+ (1-i^D)(1-\pi^u(v)) I_{j'\geq J^E} \max\{V^o(j',a',g',h',e',d_u+1), V^r(j',a',h',b^r(e',j')\}]\}$$

subject to (1) and the following constraints:

$$\underline{c} \leq c \leq \max\{\underline{c}, a/(1+\tau^c)\}, \tag{2}$$

$$a' = b^u(e,d_u)(1-i^D) + (1+r(1-\tau^k))k - Q(m(j,h,\epsilon), I_{j\geq J^M}) + x, \tag{3}$$

$$vi^D = 0, \tag{4}$$

$$e' = e, \tag{5}$$

where I is an indicator function that takes 1 if the subscript condition is true and 0 otherwise. Constraint (2) describes the consumption space. Equation (3) defines the end of period asset holdings. Equation (4) demonstrates that DI applicants are not allowed to search for jobs. Equation (5) shows that the past earning index remains constant for this category. This assumption is made to resemble that unemployment benefits are tagged to prior employment wages and the PIA is fixed at the point of losing employment due to disabilities. Note that the past earning index changes for employed individuals.

At or above the NRA (not eligible for DI):

$$V^o(j,a,g,h,e,d_u) = \max_{c,v}\{u(c,1-N^u(j,v)) + \beta s_j(h) E_{\epsilon,j',g',h'|j,g,h}[I_{j'\geq J^L} V^r(j',a',h',b^r(e',j'))$$
$$(1-\pi^u(v)) I_{j'<J^L} \max\{V^o(j',a',g',h',e',d_u+1), V^r(j',a',h',b^r(e',j'))\}$$
$$+\pi^u(v) I_{j'<J^L} \max\{V^e(j',a',g',h',e'), V^o(j',a',g',h',e',d_u+1), V^r(j',a',h',b^r(e',j'))\}]\}$$

subject to constraints (1), (2), (5), and the following:

$$a' = b^u(e,d_u) + (1+r(1-\tau^k))k - Q(m(j,h,\epsilon), I_{j\geq J^M}) + x.$$

3.7 Stationary Equilibrium

Let S denote a general state vector that records the category (e,d,r,o) and the category dependent state vectors (S^e, S^d, S^r, S^o). Let $\mathbb{S}$ denote the general state space.

Definition 1. *A stationary equilibrium is a collection of government policies, a lump-sum transfer, a private health insurance premium, policy functions, and distribution $\mu(S)$ of individuals, such that the following conditions hold.*

1. *Given government policies, a lump-sum transfer, a private health insurance premium, policy functions are the solutions to the individual problem described in subsection 3.6 and Appendix B;*

2. *The government budget is balanced:*

$$\int [\tau^s wg + \tau^c c + \tau^k rk)]\mu(S)dS = G + \int [(b^u + b^d + b^r + b^s) + (m - Q)i]\mu(S)dS;$$

3. *The private health insurance premium is determined such that insurance firms earn zero profits:*

$$\int (m - Q)(1 - i)\mu(S)dS = 0;$$

4. *Total lump-sum transfers equal the assets of deceased individuals:*

$$\int (1 - s)a'\mu(S)dS = x \int \mu(S)dS;$$

5. *The distribution of individuals is stationary.*

4 Calibration

The model is set to match the 2010 US economy. Most parameters are estimated directly from the data. Four parameters that characterize the health dependent time cost of work, the utility cost of filing DI claims, and the discount factor are jointly calibrated to match data moments.

4.1 Data

The main data source is the Medical Expenditure Panel Survey (MEPS). The MEPS is a two-year panel survey that records individual demographic features, income, health insurance coverage, health conditions, and medical costs. As of June 2014, the most recent panels are panels 14 and 15, which were surveyed around 2010. As a supplement to MEPS, I also use the 2010 Survey of Consumer Finances to obtain asset distribution, the NBER TAXSIM to obtain tax rates, and various reports from the Social Security Administration and the Centers of Medicare & Medicaid Services to obtain government program features. But 2010 is on the path of slow recovery from the Great Recession and has extended unemployment benefits, I am concerned that the 2010 statistics about labor market dynamics and DI recipients may not resemble those of a normal economic period. Thus, I use the 2006 statistics to characterize these two dimensions. In particular, job separation rates are calculated from the Current Population Survey (CPS) December 2005-December 2006; employment rates are derived from the MEPS panel 10 and 11; the percentage of DI recipients is derived from the beneficiary count in the social security annual statistical supplement and the census population estimates.

4.2 Demographics

The model has 13 age groups. The first age group corresponds to young individuals who are 20-44 years old. The second age group corresponds to middle-aged individuals who are 45-59 years old. The third to twelfth age groups correspond to those who are in the late stage of their working career, that is, 60-69, respectively. The last age group corresponds to those who are at and above age 70. The model introduces one year age groups for 60-69, because it aims to better capture the decisions of the elderly who are on the margin of retirement.

Each period in the model corresponds to four months. The transition probability between age groups ψ_j takes the value of 0.01 for people of the first age group, 0.02 for people of the second age group, 0.33 for people of the third to twelfth age group, and 0.00 for people of the last age group. Thus, on average individuals remain in the first age group for 25 years (75 periods), the second age group for 15 years (45 periods), the third to twelfth age groups for 1 year (3 periods), conditional on survival. People cannot transit out from the last age group except for death.

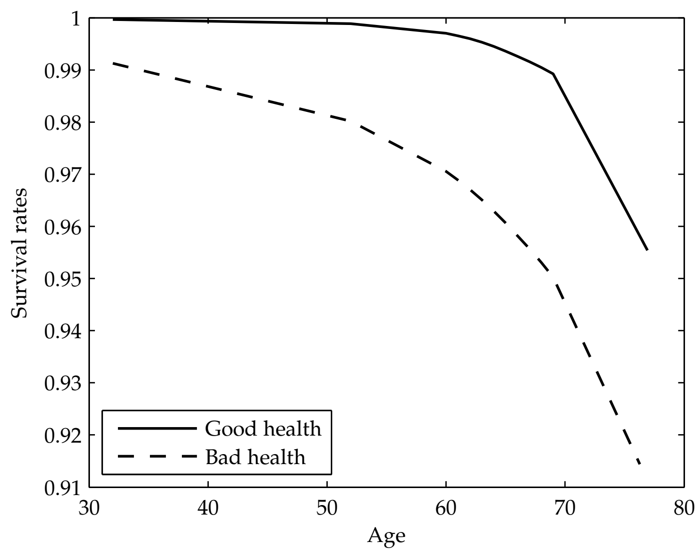


Figure 2: Survival Rates by Age and Health Status

The model allows two health status: good health and bad health. Figure 2 displays survival rates by health status, which are set to match that in Imrohoroğlu and Kitao (2012). The population size is normalized to one. Deceased individuals are replaced by newborn individuals of age group 1.

4.3 Preferences

The utility function is specified as follows:

$$u(c,l) = \frac{(c^{\eta} l^{1-\eta})^{1-\gamma}}{1-\gamma}, \tag{6}$$

where the relative risk aversion parameter γ is set to 2, as the common value used in the literature. η is set to 0.5 indicating that individuals put equal weights on consumption and leisure. The choice of η does not play an important role in the model, because the time cost of employment is calibrated to match the data.

Following Kitao (2014), the search cost is specified as follows:

$$N^u(h,v) = N^e(h)(1-(1-v)^{0.98}), \tag{7}$$

The above function assumes that the time cost of searching at the full effort is the same as employment. The curvature parameter is set to 0.98, as in Alvarez and Veracierto (2001). In the model, the majority of individuals choose the full effort if search, so the job finding rate $\pi^u(v)$ is set to v in order to match that the average unemployment duration was 16.8 months in 2006 (Fred).

The health dependent time cost is set to match that 86.5 percent of good health individuals aged 45-59 are employed and that 53.1 percent of bad health individuals aged 45-59 are employed.[3] Calibration suggests that the time cost of employment is 0.367 for good health

[3] Data is from the MEPS panel 10 and 11. The sample excludes people who are full-time or part-time

individuals and 0.738 for bad health individuals.

The discount factor β is used to target the ratio of average assets of individuals aged 45-59 to average wage earnings. The average assets for households with the household head aged 45-59 in 2010 were \$252 thousand (Survey of Consumer Finances).[4] The average wage earnings in 2010 were \$39,959 (Social Security Administration). Since a typical household has two adults, the ratio was 9.44 (=(251560/2)/(39959/3)). To meet this target, β is assigned to 0.996. The pre-tax interest rate is set to 0.05 per annum, as the value summarized in Cooley (1995).

4.4 Labor market

The skill level g ranges from 0.1 to 1.0. All newborn individuals enter the economy at the lowest skill level of 0.1. The transition matrices $\gamma_j^e(g, g')$ that characterize the skill accumulation of employed individuals are set to match the growth in annual real wages for people who were continuously employed for two consequent years. The data shows the average growth rate is 6.0 percent for individuals aged 20-44, 0.5 percent for individuals aged 45-59, and -0.3 percent for individuals aged 60-69 (MEPS). The negative growth rate may be a result of partial retirement. Since the model abstracts from partial retirement, it sets the annual growth rate of the 60-69 age group to 0.0. The unit wage rate w is assigned to \$141k per annum in order to match that workers of age 20 on average earn \$14,106. The transition matrices $\gamma_j^o(g, g')$ that characterize the skill depreciation during employment gap

students. A respondent is counted as employed if he/she was employed at the interview date, had a job to return at the interview date, or had a job during the reference period.

[4] All dollar values in the paper are denominated in 2010 constant dollars unless stated otherwise. Since the model is not designed to capture the decisions of the super-rich, the sample drops the respondents who are in the top 5 percent of the wealth distribution (with assets larger than \$1,866 thousand).

is set to match the 15 percent per annum used by Pavoni and Violante (2007). Appendix C.2 reports the skill vector and transition matrices.

The job separation rate $\sigma(j)$ is set to replicate the percentage of employed workers who recently lose their jobs and keep searching for new jobs. Appendix C.3 details the procedure of estimation. The annual job separation rate is 0.239, 0.128, 0.128, 0.157 for individuals aged 20-44, aged 45-59, aged 60-64, and aged 65-69, respectively. The observed large job separation rate among young people is in line with the results of Elsby et al. (2010).

4.5 Health, Medical Expenditures, and Health Insurance

The health measure is derived from the MEPS's question about perceived health status, which is answered on a 1 (excellent) to 5 (poor) scale. Following Imrohoroğlu and Kitao (2012), bad health is defined as having an average score (over a year span) larger than 3, and good health is defined as having an average score smaller than or equal to 3. Newborn individuals are assumed to enter the economy with good health. Table 1 reports health transition matrices $\gamma_j(h, h')$.

Table 1: Annual Transition Probabilities of Health Status by Age

Age	Health	Good	Bad	Age	Health	Good	Bad
20-44	Good	0.954	0.046	65-69	Good	0.918	0.082
	Bad	0.428	0.572		Bad	0.245	0.755
45-59	Good	0.910	0.090	70+	Good	0.851	0.149
	Bad	0.308	0.692		Bad	0.285	0.715
60-64	Good	0.913	0.087				
	Bad	0.265	0.735				

Data: MEPS panel 15.

Conditional on age and health status, medical expenses $m(j, h, \epsilon)$ are asymmetrically distributed: a large fraction of people consume small amounts of medical goods and a small fraction of people consume large amounts. To replicate this feature, the model introduces three types of health spending shocks: a low shock with a probability of 0.6, a medium shock with a probability of 0.35, and a high shock with a probability of 0.05, which, respectively, correspond to the bottom 60 percent, the next 35 percent, and the top 5 percent of the expenditure distribution. Table 2 reports the values.

Table 2: Annual Medical Expenditures by Age and Health Status

Age	Health	0-60%	61-95%	96-100%	Age	Health	0-60%	61-95%	96-100%
20-44	Good	156	2,485	18,727	65-69	Good	1,353	8,610	52,416
	Bad	735	8,818	52,843		Bad	3,856	23,987	102,758
45-59	Good	479	4,548	31,607	70+	Good	1,948	10,509	48,524
	Bad	1,971	16,365	73,106		Bad	4,687	26,959	92,737
60-64	Good	1,010	6,670	36,844					
	Bad	3,198	24,473	93,849					

Data: MEPS panel 14 and 15.

Private health insurance has a coinsurance rate q_o of 17.7 percent, which is the ratio of average out-of-pocket payments to average medical expenses among people under age 65 and covered by private insurance (MEPS). The coinsurance rate for public health insurance q_1 is set to 12.2 percent, which is the ratio of average out-of-pocket payments to average medical expenses among people at and above age 65 (MEPS). To capture the 24 month waiting period for Medicare eligibility among DI recipients, the probability of receiving insurance shock π^M is assigned to 0.2. The Medicare premium P_1 is assigned to an annual rate of \$1,709, which is the sum of Part B and Part D premiums (Centers Medicare & Medicaid Services). The private health insurance premium P_0 is an endogenous variable and takes the value of \$2,861 per annum in the benchmark economy.

4.6 Government

Old-Age Insurance: In order to calculate social security benefits, the model defines the past earning index e as follows:

$$f_j(e,x) = \begin{cases} (12 \times 3 \times e + x)/(12 \times 3 + 1) & \text{if } j = 1 \\ (32.5 \times 3 \times e + x)/(32.5 \times 3 + 1) & \text{if } j = 2 \\ \max\{e, ((35 \times 3 - 1)e + x)/(35 \times 3)\} & \text{if } J^L > j \geq 3, \end{cases} .$$

where 12×3 and 32.5×3 are the average number of periods experienced by individuals in the first and second age groups, respectively. To capture that the Social Security Administration only considers the highest 35 years of earnings in calculating PIA, from the age of 60, the past earning index is updated only if current earnings are greater than the index.

The PIA is a piecewise linear function of the past earning index:[5]

$$PIA(e) = \begin{cases} 0.9e & \text{if } e < 3044 \\ 2739.6 + 0.32(e - 3044) & \text{if } 18344 > e \geq 3044 \\ 7635.6 + 0.15(e - 18344) & \text{if } 35600 > e \geq 18344 \\ 10224 & \text{otherwise.} \end{cases}$$

Following social security rules, the model sets the ERA to 62, NRA to 66, and LRA to 70. If a claim is filed at the NRA, the beneficiary will receive his/her PIA. If a claim is filed prior to the NRA, benefits are reduced by 5/9 of one percent for each month for the first 36 months and 5/12 of one percent for the rest months. If a claim is filed after the NRA,

[5]Recall that each period represents 4 months, and hence the bend points used in the model are 3 times larger than the monthly bend points.

benefits are adjusted upwards by 2/3 of one percent for each month of wait. The adjustment factors used by the benchmark economy is illustrated by the solid line in Figure 1.

Disability Insurance: The benchmark economy allows DI recipients to receive their PIA regardless of the age of awards. The DI award rate $\pi^d(h)$ is set to 0 for good health individuals and 0.28 for bad health individuals. 0.28 is the percentage of applicants awarded DI benefits at the initial claim level (Annual Statistical Report on the Social Security Disability Insurance Program).[6]

The utility cost of filing a DI claim is:

$$u^d(j) = (I_{j\leq 2} + (\frac{8-j}{13})^2 I_{3<j\leq 8})d,$$

where d controls the degree of disutility. In order to capture that DI screening is more lenient for the elderly, the model allows the utility cost to drop from the high level of d for young and middle-aged individuals to the low level of 0 for individuals aged 65 and above in a quadratic way. d takes the value of 0.074 to match that 5.7 percent of the civilian population aged 45-49 were DI workers' recipients in 2006 (social security annual statistical supplement).

Unemployment Insurance: The amount of unemployment benefits is set to match that unemployment benefits replace 46 percent of past earnings up to 6 months (Department of

[6] The model abstracts from type II errors of failing to reject undeserved applicants in DI screening. This assumption is supported by the DI screening patterns documented in Low and Pistaferri (2012), which shows that the probability of falsely accepting people of good health is very small: ranges from 0.003 for people under age 45 to 0.014 for people at and over 45. Furthermore, "the SSA also performs a quality review sample of both allowances and denials, and the DDS net accuracy rate has been 97% or better over the last 3 years" (Lyon-Hart, 2013).

Labor):

$$b^u(e, d_u) = (0.46 I_{d_u=0} + 0.23 I_{d_u=1})e$$

To reduce the size of state variables, the model sets the maximum duration of unemployment $\overline{d^u}$ to 2. This simplification does not affect results because conditional on other state variables individuals with more than 3 periods of unemployment do not differ from individuals with exactly 3 periods of unemployment.

Social Insurance: Social insurance provides a consumption floor $\underline{c}$ of $4,000, which is within the range of values used by Pavoni and Violante (2007) ($4,053), De Nardi et al. (2010) ($3,612), and Kitao (2014) ($4,066).

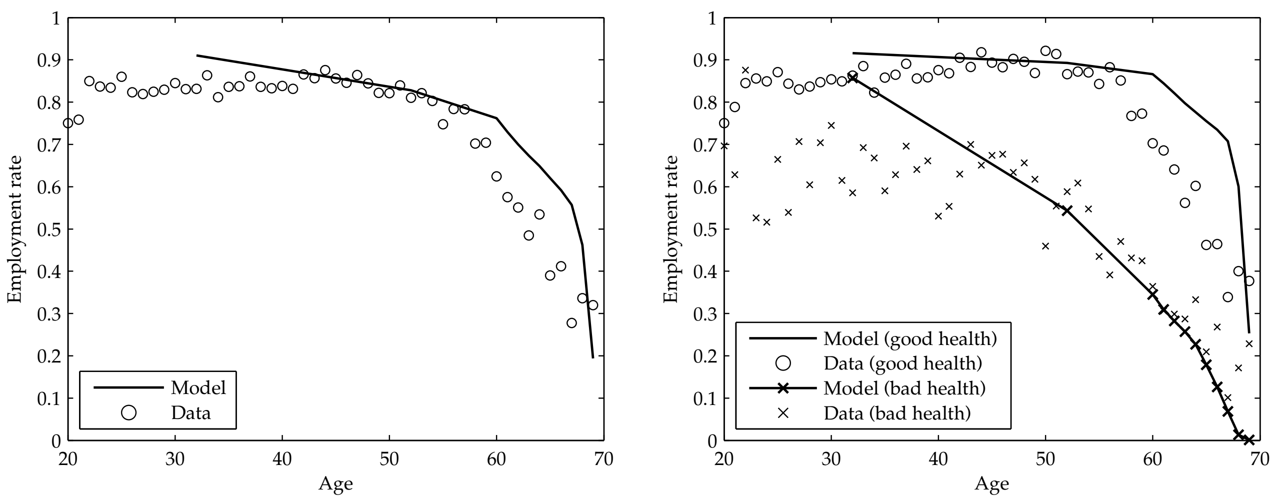
Taxes and Direct Spending: The government collects three type of taxes. The labor tax rate is set to 25.82 percent, and the capital tax rate is assigned to 28.1 percent (NBER TAXSIM). The consumption tax rate is set to 6.8 percent, which is the average sales tax rate across states with sales tax. Direct spending G is a residual that balances the government budget. G takes the value of $1,831 per capita per annum in the benchmark economy.

5 Evaluation

In order to evaluate the model's predictive power, this section presents statistics about the benchmark economy and describes responses towards the past OAI reform.

5.1 Benchmark Economy

Employment: The model targets the employment rates of people aged 45-59, but not the rest age groups. Figure 3 displays life-cycle profile of employment. Note that the model line is plotted by connecting average values of different age groups. The model fairly well matches the decline in employment over the life cycle, in particular, it closely captures the decline in employment among bad health individuals aged 60 and beyond. This is because the model properly incorporates the value of dropping out of the labor force by considering both DI and OAI. The model slightly over-predicts the employment rate for young people who are age 44 and under, since it abstracts from the time cost of raising children.



(a) Average

(b) By health status

Figure 3: Employment Rates by Age

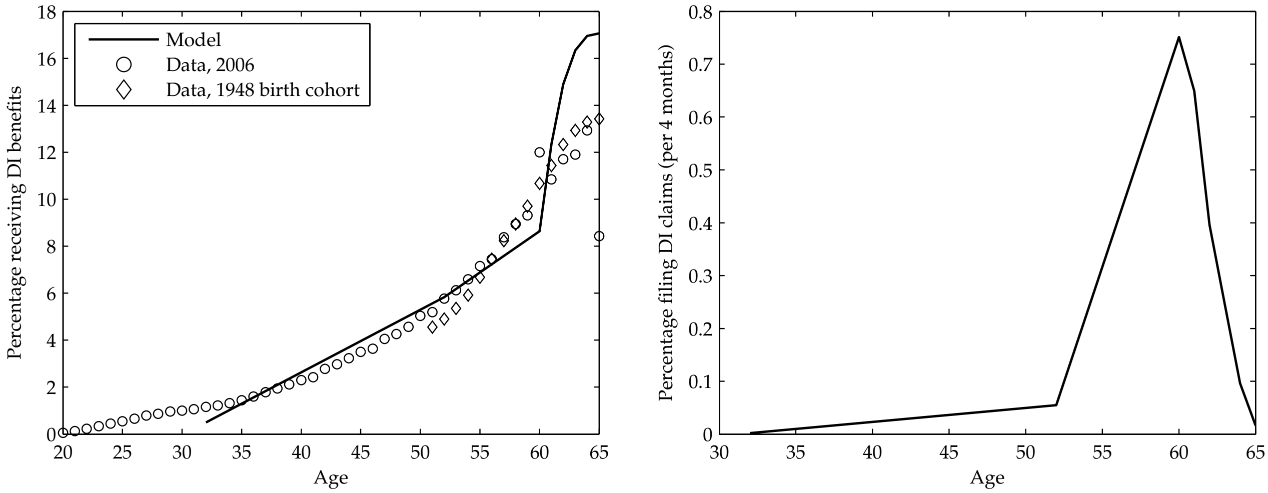
Notes: Data numbers are calculated from the MEPS panel 10 and 11.

Disability Insurance: Figure 4(a) compares the percentage of people receiving DI benefits in the model with that in the data. The model is calibrated to match the DI recipient rate among people aged 45-59, but not other age groups. The model is capable of generating a low DI recipient rate among the youth and a high DI recipient rate among the elderly because of three features. First, forgone earnings drops as people age. Second, the probability of being of bad health rises with age. Third, DI screening is more lenient for old workers.

The model slightly overstates the percentage of people aged 62-65 receiving DI benefits because data numbers reflect current DI recipients. Given that the DI screening process may take several years, in the data, the time of awards can be later than the time of entitlements. The model does not distinguish the award time from the entitlement time, hence the model number should be greater than the data. Furthermore, the data shows that many people file an OAI claim at the ERA of 62 and give up the option value of filing a DI claim between the ERA and the NRA. Benıtez-Silva et al. (2007) argue that this is due to the perceived uncertainty of future benefit reductions: individuals want to claim early at a cost to eliminate such uncertainty. Since this paper abstracts from this uncertainty, compared to the data, people in the model are more likely to file DI claims between the ERA and the NRA.

The number of DI recipients is a stock variable that includes both past surviving DI recipients and new enrollees. To provide a better picture about the flows into DI, Figure 4(b) displays the life-cycle profile of DI applications. This profile is hump-shaped and has the maximum reached at age 60. The three reasons that explain the increase in DI recipients also account for the initial increase in DI applications. Starting from the age of 61, we observe fewer people file DI claims due to the selection that the majority of individuals who want to take DI as an early retirement pathway have been already on the DI rolls before that age.

Consumption and Assets: Table 3 presents the consumption and asset profiles of



(a) Recipients

(b) Applications

Figure 4: Disability Insurance Recipients and Applications by Age

Notes: Data numbers are computed as the ratio of DI worker recipients (social security annual statistical supplement, 2000-2013) to the population estimates (Census Bureau). Circle markers display the percentage for the year of 2006, and diamond markers display the percentage for the 1948 birth cohort. People of different birth cohorts in 2006 may be subject to different OAI rules. In particular, people aged 65 in 2006 has a NRA of 65 years old and 8 months, and are transferred to the OAI rolls once the NRA is reached. By contrast, the 1948 birth cohort faces the same OAI benefit rules as individuals in the benchmark economy.

the benchmark economy. The consumption profile is hump-shaped. The observation that consumption does not substantially drop following retirement is consistent with recent findings of Attanasio and Weber (2010) and Aguiar and Hurst (2013). The model correctly matches the average asset level, but over-predicts asset accumulation for the youth and asset decumulation for the elderly. The over-prediction for the youth is expected since the model abstracts from child care cost, college debts, and the opportunity to share risks via family transfers. The under-prediction for the elderly is also expected since the model abstracts from housing assets and bequest motives.

Table 3: Consumption and Assets by Age

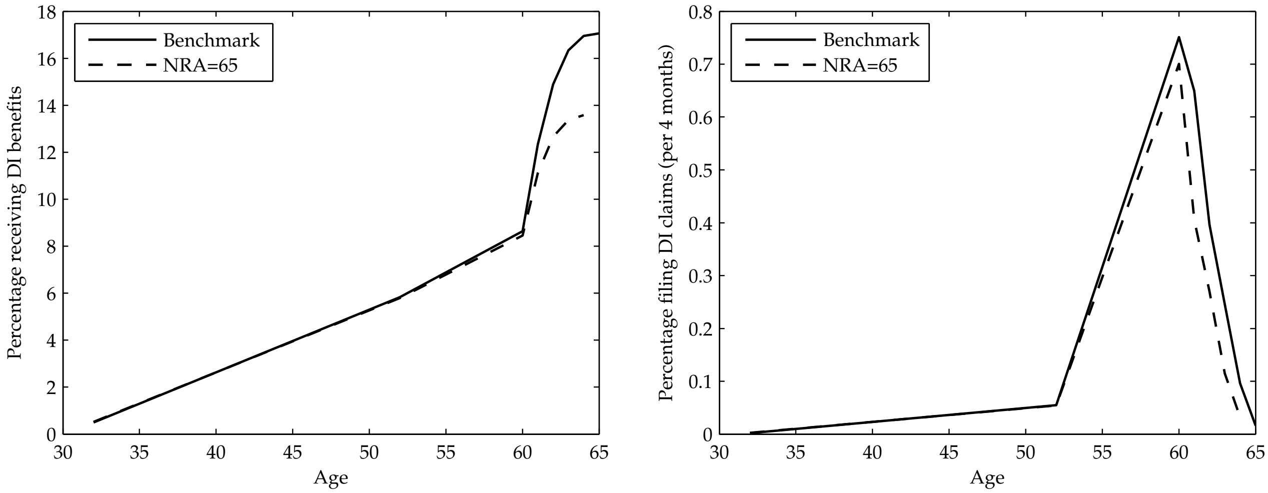
	Annual Consumption	Assets	
Age	Model	Model	Data
20-44	24043.1	87192.3	41831.8
45-59	24447.4	131067.6	125780.3
60-65	26262.0	126628.2	163636.7
66-69	25620.6	108268.3	163849.1
70+	19630.1	47389.7	161081.0
Average	23431.5	92928.9	102351.7

Notes: Data numbers are constructed from the net worth variation in the 2010 Survey of Consumer Finances. The sample excludes respondents in the top 5 percent of the wealth distribution. The reported individual assets are calculated from household assets under the assumption that there are two adults in each household.

5.2 Past OAI Reform

In order to compare model's predictions with literature estimates, this section constructs a counterfactual economy in which the retirement benefit rules are set to match those of the 1937 birth cohort, the last cohort with a NRA of 65. The difference between the new economy and the benchmark economy is attributed to the past OAI reform, that is, the change in OAI benefit rules from 1937 to 1943-54 birth cohorts.

Disability Insurance: As shown in Figure 5, the past OAI reform increases the number of DI applicants and DI recipients. In particular, the percentage of DI recipients among people aged 45-64 rises by 0.5 percentage points (from 7.3 to 7.8 percent). This predicted increase is very close to the estimate of 0.6 percentage points in Duggan et al. (2007). The model predicts that people are more likely to enroll into DI after the OAI reform via income and substitution effects. The income effect indicates that people are more willing to pay the utility cost of filing DI claims given the drop in wealth. The substitution effect implies that declining generosity of OAI reduces the opportunity cost of filing DI claims.



(a) Recipients

(b) Applications

Figure 5: Effects of the Past OAI Reform on DI

Mitchell and Phillips (2000) and Bound et al. (2010) also study the increase in DI claims resulting from OAI benefit decreases, but they find a much smaller increase than this model does. My model differs from their models by considering the changes in consumption-saving decisions and employment dynamics. Specifically, individuals in my model accumulate more assets in response to the decrease in OAI benefits. A large asset stock helps reduce the consumption difference between workers and DI recipients, and hence raises DI claims.

Labor Supply: This reform raises the labor force participation rate from 69.5 to 69.8 percent and the employment rate of people aged 20-69 from 82.7 to 82.9 percent. Taken into account the changes in skills, labor supply rises at a smaller rate of 0.3 percent. It is important to mention that empirical evidence from Pingle (2006), Mastrobuoni (2009), and Blau and Goodstein (2010) also suggests that the past OAI reform raises labor supply, employment, and labor force participation. Since the margin people staying in the labor force are of low skill levels and choose low search intensity, the past reform leads to a slight increase in the unemployment rate.

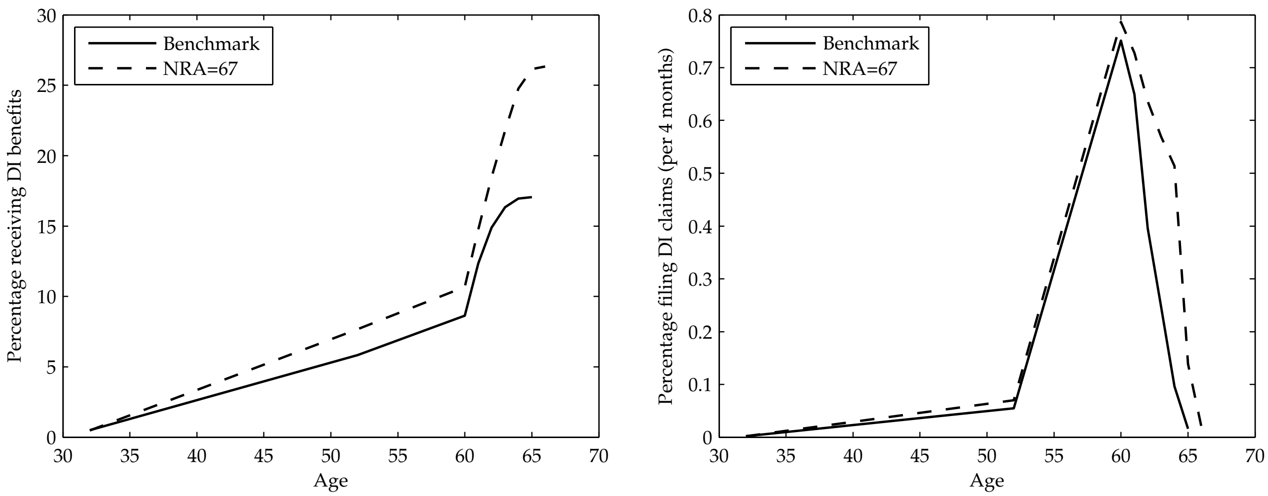
6 Social Security Reforms

This section considers several social security reforms. The first one replicates the scheduled OAI reform that raises the NRA from the current level of 66 to the future level of 67. With the NRA fixed at 67, this section compares two alternative DI reforms that both reduce DI spending near its current level, but one reform targets the elderly and the other reform targets individuals of all ages. The labor tax rate is kept unchanged in all economies due to the concern that the government is unlikely to reduce social security taxes given the long-term solvency issue. Instead, government budget is balanced by adjusting direct spending.

6.1 Future OAI Reform

In order to understand the effects of the future OAI reform, this part constructs a counterfactual economy in which the OAI benefit rule is set to replicate that of the 1960 and later birth cohorts, who have a NRA of 67. The difference between the benchmark economy and the new economy is attributed to the future OAI reform, that is, the change in OAI benefit rules from 1943-54 to 1960 and later birth cohorts.

Disability Insurance: As Figure 6 shows, this future reform will have a much larger impact on DI than the past reform, in particular, the percentage of people aged 45-64 on the DI rolls rises by 2.5 percentage points, which is four times greater than the response to the past OAI reform. Furthermore, the future reform substantially incentivizes people older than the ERA to file DI claims: the percentage of people filing DI claims at age 63 rises from 0.3 to 0.6, and the percentage at age 64 rises from 0.1 to 0.5. The increase in DI applicants and recipients under the future reform is much greater than that under the past reform, because in the past individuals can avoid the decrease in social security wealth by either becoming DI recipients or delaying the age of claiming OAI benefits, but in the future, becoming DI recipients is the only option to avoid the drop in social security wealth.



(a) Recipients (b) Applications

Figure 6: Effects of the Future OAI Reform on DI

Labor Supply: Table 4 presents labor market statistics. The comparison between columns (1) and (2) shows that this reform leads to a 1.1 percent drop in labor force participation rate and a 1.0 percent drop in the employment rate of people aged 20-69. Both age groups 20-59 and 60-69 experience declines in employment, but the response of the older age group is larger than that of the younger age group. Taking into account the change in skill levels, labor supply drops by 0.4 percent. Given the margin people exiting the labor force

Table 4: Labor Market by Economy

NRA	66(Benchmark)	67	67	67
DI reform	No	No	Elderly	All
	(1)	(2)	(3)	(4)
Labor force participation rate	69.78	69.04	70.12	70.14
Employment rate (20-69)	82.93	82.11	83.19	83.36
for age group 20-59	88.10	87.65	87.58	88.59
for age group 60-69	59.96	57.48	63.74	60.15
Unemployment rate	7.70	7.64	7.85	7.69
Labor supply*	100.00	99.61	100.18	100.32

Notes: All numbers are percentage. * normalizes the benchmark economy value to be 1. Column (1) corresponds to the benchmark economy. Column (2) corresponds to an economy under the future OAI reform. Column (3) corresponds to an economy under the DI reform targeting the elderly. And column (4) corresponds to an economy under the DI reform targeting all individuals.

are people of relatively low skills, the future OAI reform raises the average search intensity and reduces the unemployment rate.

Differed from the predictions of existing literature (Gustman and Steinmeier, 1985; Imrohoroğlu and Kitao, 2012), my model suggests that the future OAI reform reduces labor supply. This is because the model considers that decreases in OAI benefits induce more individuals to stop working and file DI claims. The new applicants who are awarded benefits will permanently leave the labor force, and those who are denied benefits are also unlikely to regain employment afterwards because they suffer from skill depreciation (Autor et al., 2015). Moreover, the increased probability of exiting the labor force at an early age as a DI recipient disincentivizes individuals to accumulate skills: compared to the benchmark economy, individuals aged 20-59 in the new economy are less likely to obtain a skill level equal to or greater than 0.5 (the fourth highest skill level).

Government Budget: Table 5 describes the government budget. The comparison

Table 5: Government Budget by Economy (Annual, Per Capita)

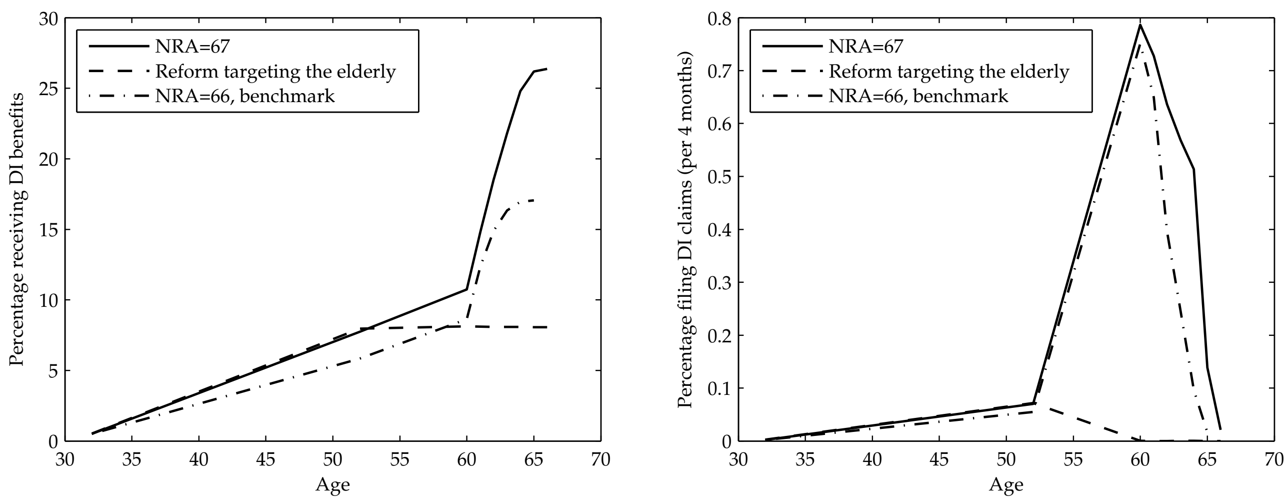
NRA	66 (Benchmark)	67	67	67
DI reform	No	No	Elderly	All
	(1)	(2)	(3)	(4)
Tax revenue	9617.7	9627.6	9667.6	9677.0
Labor	6833.0	6806.4	6845.1	6854.8
Capital	1191.4	1235.5	1232.8	1235.2
Consumption	1593.3	1585.6	1589.6	1587.0
Transfer spending	7787.2	7640.8	7556.6	7491.5
DI	311.0	448.6	312.3	304.5
OAI	4427.8	4138.4	4179.4	4140.9
Unemp. insurance	853.3	846.7	861.3	857.6
Medicare	2080.2	2104.8	2076.0	2071.2
Social insurance	114.8	102.3	127.6	117.2
Direct spending	1830.5	1986.8	2111.0	2185.5

Notes: Column (1) corresponds to the benchmark economy. Column (2) corresponds to an economy under the future OAI reform. Column (3) corresponds to an economy under the DI reform targeting the elderly. And column (4) corresponds to an economy under the DI reform targeting all individuals.

between Column (1) and (2) indicates that this reform reduces OAI expenses from $4,428 to $4,139 per year per capita. It raises capital taxes since people accumulate more assets to compensate for the drop in OAI wealth. As the asset stock is larger, individuals in the new economy are less likely to receive consumption floor transfers, and the government saves money on social insurance. But, this reform reduces labor taxes and raises DI spending from $311 to $447 per year per capita. One third of the increase in DI spending is attributed to the benefits paid to people aged 66, who are transferred to the OAI rolls in the benchmark economy. The rest of the increase is attributed to the rising DI enrollments. The additional spending on DI is equivalent to 47.5 percent of OAI savings.

6.2 DI Reform Targeting the Elderly

CBO (2012) examines a set of DI reforms, including a reform that targets the elderly. Under this reform, starting at age 53, benefits of new DI recipients are reduced by 3 percent, with an additional 3 percent reduction occurring at each subsequent year of age. From the ERA benefits start to increase, and new recipients between 62 and 66 years old receive a benefit amount that is equal to their OAI benefits at that age. The model is incapable of replicating the exact reform, and hence the considered reform starts DI benefit decrease from age 60.



(a) DI recipients

(b) DI Applications

Figure 7: Effects of DI Benefit Reductions for Individuals Aged 53 and above

Disability Insurance: As shown in Figure 7, this DI reform substantially disincentivizes people aged 60 and above to file a DI claim, but it induces more young and middle-aged individuals to stop working and file DI claims. This shift in the DI enrollment age could be costly because it shortens the duration as a worker and lengthens the duration as a DI recipient. Overall, in this economy, the percentage of people aged 20-66 on the DI rolls is 29.4 percent lower than in an economy without the reform.

Labor Supply: As reported in Table 4, compared to the previous economy, this DI reform raises the labor force participation rate by 1.6 percent, the employment rate of people aged 20-69 by 1.3 percent, and labor supply by 0.6 percent. The overall increase in employment masks the important fact that this reform indeed discourages employment among young and middle-aged individuals. Moreover, this economy has a high unemployment rate, since many elderly individuals who are likely to choose low search intensity stay in the labor force.

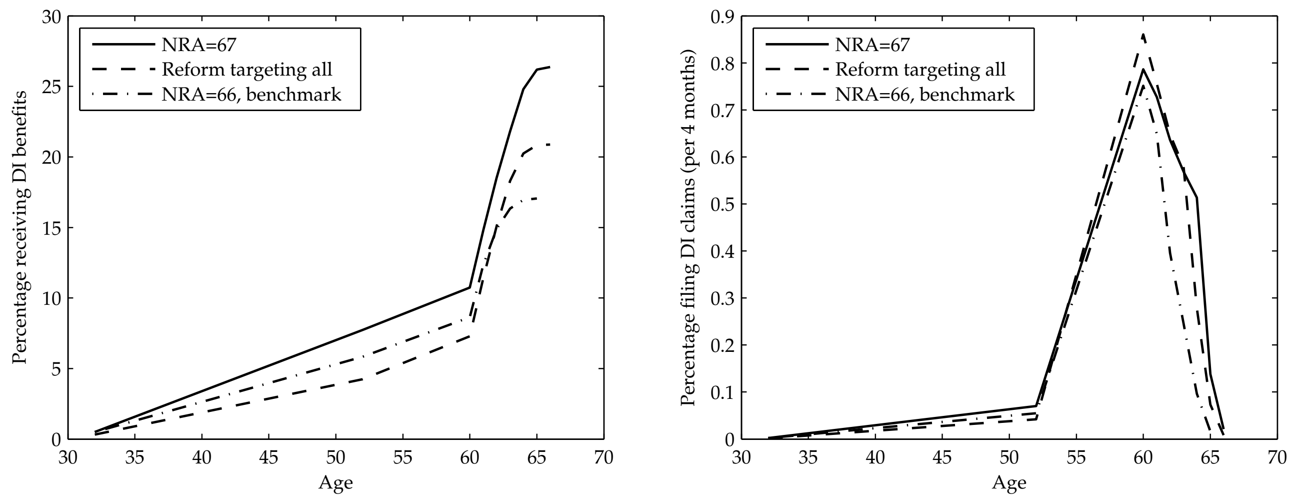
Government Budget: This reform reduces DI spending to a level that is close to the benchmark economy, but has side effects on the other transfer programs. OAI spending is greater, because the reform induces people to work at an old age and build up average earnings. The spending on unemployment insurance and social insurance is also greater because more people stay out of the social security rolls and use these services. But, Medicare spending is smaller since fewer people are eligible for DI reasons.

6.3 DI Reform Targeting All Individuals

The alternative DI reform reduces DI benefits for all individuals by 1.9 percent.

Disability Insurance: As Figure 8(b) displays, this DI reform disincentivizes young and middle-aged people to file a DI claim but does not deter the elderly from enrolling into the DI rolls. Overall, in this economy, the percentage of people aged 20-66 on the DI rolls is 32.2 percent lower than in an economy without the reform.

Labor Supply: As presented in Table 4, this DI reform induces a greater increase in



(a) DI recipients (b) DI Applications

Figure 8: Effects of DI Benefit Reductions for Individuals of All Ages

labor force participation, employment, and labor supply than the first DI reform does. Most importantly, this reform encourages individuals of all ages to work more. In particular, people aged 60-69 in the new economy are 4.6 percent more likely to be employed than in an economy without this reform. This large gain in employment is attributed to both the decrease in DI benefits and the induced increase in skill levels, for instance, individuals aged 60-69 in this economy are 0.2 percent more likely to have a skill level equal to or greater than 0.5 than those in an economy without this reform.

Government Budget: As Table 5 shows, this DI reform targeting all individuals produces a similar level of DI savings to the previous reform. Different from the previous reform, this reform also generates savings on OAI, unemployment insurance, and social insurance. This is because this reform induces more individuals aged 60 and beyond to exit the labor market permanently.

6.4 Comparing Two DI Reforms

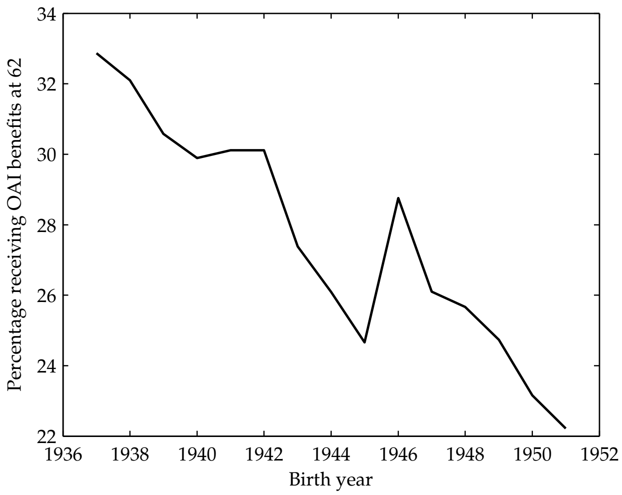
If look at long-run ex-ante utility, the second reform targeting all individuals is preferred to the first reform targeting the elderly. But, in the short run, the first reform may generate greater DI savings and more employment than the second reform. This is because the gains of the second reform largely rely on skill improvements. Given skill levels are fixed in the short run, a radical reform like the first one might be more efficient than a mild reform like the second one in achieving certain policy targets.

7 Discussion

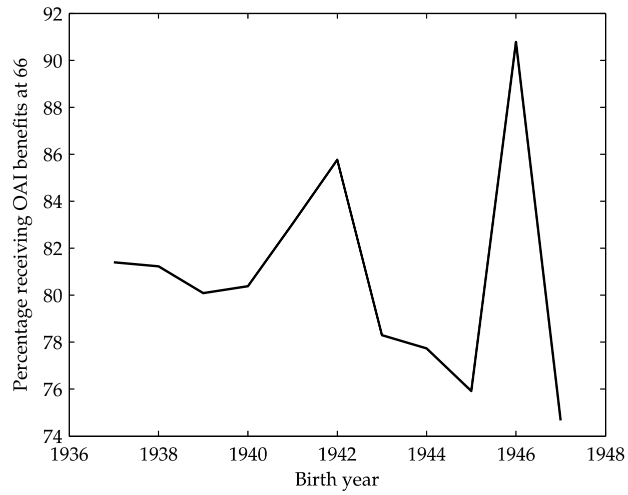
This section discusses key assumptions.

7.1 DI Claiming Decisions

In order to understand the role of DI claims, this section constructs an alternative model, which removes DI but is otherwise identical to the benchmark model. This new model suggests that the future OAI reform that raises the NRA from 66 to 67 would increase labor supply by 0.2 percent. This finding indicates that if omit changes in DI claims, predictions of my model is similar to that of previous models (Gustman and Steinmeier, 1985; Imrohoroğlu and Kitao, 2012): both suggest decreases in OAI benefits encourage labor supply. A simple back-of-the-envelope calculation implies that the responses associated with DI claims account for a 0.6 ($= 0.2 + 0.4$) percent drop in labor supply.



(a) 62 Years Old



(b) 66 Years Old

Figure 9: Percentage of OAI recipients by Birth Cohort

Note: The y-axis displays the ratio of OAI worker recipients to the Census population estimates (social security statistical supplement).

7.2 OAI Filing Decisions

The model assumes that people are willing to adjust the age of filing OAI claims. This assumption can be examined using the cross-cohort variation in the data, since younger cohorts are expected to delay OAI claims in response to decreases in OAI benefits. As Figure 9 displays, consistent with the model, over time more and more individuals choose to delay the age of claiming OAI benefits, expect for the 1941, 1942, and 1945 birth cohorts who were, respectively, 66, 65, and 62 when the Great Recession started and who were of an age at which the Great Recession may largely affect their claiming decisions. Excluding these three cohorts, there is a clear pattern of delaying OAI claims. However, this pattern also indicates that the observed age distribution of OAI recipients is not stationary and hence is improper to be compared to the model's distribution.

8 Conclusion

This paper considers the rising DI claims resulting from decreased OAI benefits and analyzes the long-term effects of several social security reforms. Findings suggest that the future OAI reform reduces labor supply and increases DI spending. A DI reform targeting all individuals is preferred to a DI reform targeting the elderly, because the latter policy encourages young and middle-aged individuals to work and accumulate skills.

This paper focuses on the spillover from OAI reforms on DI, but there are other spillover effects that can be explored. For example, several recent papers (Lindner and Nichols, n.d.; Rutledge, 2011; Inderbitzin et al., 2014) find that changes in unemployment benefits affect DI application decisions. An extension of this model can be used to identify an optimal social transfer package that considers all types of program interactions. In addition, the model can be extended to incorporate business cycle fluctuations. The new model will be able to capture the dynamic impact of unemployment insurance extensions on DI and OAI. These extensions are left for future studies.

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Appendices

A Simple Model

This model aims to illustrate the main mechanisms: a decrease in OAI wealth raises the demand for DI and may reduce labor supply.

A.1 Setup

Individuals in the model live for a maximum life span of two periods. s denotes the probability of surviving to the second period. Individuals are endowed with zero assets and a skill level, denoted by $g \geq 0$. In the first period, individuals choose between three categories: employed individuals, DI recipients, and OAI recipients. Employment brings wage income g, but incurs a utility cost u^e. DI recipients receive a benefit amount of $b^d(g)$ but experience a utility cost of u^d. Note that this model abstracts from heterogeneity in health and assumes all individuals filing DI claims are awarded benefits. OAI recipients receive a benefit amount of $b^r(g, 1)$ at no cost. Individuals can borrow or save to smooth consumption. For simplification, the model abstracts from discount factors and interest rates.

In the second period, individuals who are awarded DI or OAI benefits in the first period keep receiving the same amount of benefits; individuals who choose to be employed in the first period stop working and receive a larger OAI benefit: $b^r(g, 2) = (1 + s)b^r(g, 1)/s$. The adjustment of OAI benefits by period is actuarially fair.

A.2 Parameterization

Preferences are specified in the following form:

$$\ln(c_1) - I_{e=1}u^e - I_{d=1}u^d + s\ln(c_2),$$

where c_t denotes the consumption in period t, e indicates whether the person is employed in the first period, d indicates whether the person is a DI recipient.

The social security benefit formula is set to:

$$
\begin{aligned}
b^d(g) =& bg + c, \\
b^r(g,1) =& (bg + c)P,
\end{aligned}
$$

where b and c are parameters governing the progressiveness of the benefit program. P is the key policy variable that controls the generosity of OAI.

A.3 Individual Problem

Formally, the individual problem can be written as follows:

$$\max_{e,d,c_1,c_2} \ln(c_1) - I_{e=1}u^e - I_{d=1}u^d + s\ln(c_2)$$

subject to

$$c_1 + c_2 = I_{e=1}(g + b^r(g,2)) + I_{e=0,d=0}2b^r(g,1) + I_{d=1}2b^d(g), \tag{8}$$

A.4 Benchmark Economy

The benchmark economy sets OAI benefits as generous as DI benefits ($P = 1$) and has the following property.

Proposition 1. *With $P = 1$, there exists a cutoff level of g_0^* such that in the first period individuals with $g \geq g_0^*$ choose to be employed and individuals with $g < g_0^*$ choose to be OAI recipients.*

Proof. From the individual problem described in A.3, we have the following life time utility:

$$
\begin{aligned}
\text{Employed individuals:} \quad V^e(g) =& (1+s)\ln(\frac{g}{1+s} + \frac{b^r(g,1)}{s}) + s\ln s - u^e, \qquad (9) \\
\text{OAI recipients:} \quad V^r(g) =& (1+s)\ln(\frac{2b^r(g,1)}{1+s}) + s\ln s, \qquad (10) \\
\text{DI recipients:} \quad V^d(g) =& (1+s)\ln(\frac{2b^d(g)}{1+s}) + s\ln s - u^d. \qquad (11)
\end{aligned}
$$

By comparing the life-time utility, it is easy to show that $V^r(g) > V^d(g) \quad \forall g$; and $V^e(g) > V^r(g)$ if and only if $g > \frac{\exp(u^e/(1+s))2c/(1+s)-c/s}{1/(1+s)+b/s-\exp(u^e/(1+s))2b/(1+s)} = g_0^*$. Note that the cutoff level g_0^* can be zero, in which case the employment cost is too small such that all individuals choose the employment category in the first period. □

A.5 Decreased OAI Benefits in an Economy with DI

Next, consider a policy that reduces OAI generosity ($P < 1$) but keeps DI generosity unchanged.

Proposition 2. *With $P < 1$ and $u^d < (1+s)\ln\frac{1}{P}$, the decision of filing OAI claims in the first period is dominated by the decision of filing DI claims.*

Proof. The assumption indicates that $V^d(g) - V^r(g) > 0, \forall g$. □

Proposition 3. *With $P < 1$ and $u^d < (1+s)\ln\frac{1}{P}$, there exists a cutoff level of g_1^* such that in the first period individuals with $g \geq g_1^*$ choose to be employed and individuals with $g < g_1^*$ choose to be DI recipients.*

Proof. The comparison between $V^e(g)$ and $V^d(g)$ implies that people choose to be employed if and only if $g > \frac{\exp(\frac{u^e-u^d}{1+s})2sc-(1+s)cP}{s+(1+s)bP-\exp(\frac{u^e-u^d}{1+s})2sb} = g_1^*$. □

The above proposition illustrates that a decrease in OAI benefits raises the number of DI recipients.

Proposition 4. *With $P < 1$ and $u^d < (1+s)\ln\frac{1}{P}$, a decrease in OAI benefits may reduce labor supply.*

Proof. Let define Δg^* as:

$$\Delta g^* = g_1^* - g_0^* = \frac{\exp(\frac{u^e-u^d}{1+s})2sc - (1+s)cP}{s+(1+s)bP - \exp(\frac{u^e-u^d}{1+s})2sb} - \frac{\exp(\frac{u^e}{1+s})\frac{2c}{1+s} - \frac{c}{s}}{\frac{1}{1+s} + \frac{b}{s} - \exp(\frac{u^e}{1+s})\frac{2b}{1+s}}. \tag{12}$$

It is easy to show that this function Δg^* is continuous and monotonically declining with respect to u^d. Since this function takes a positive value at $u^d = 0$, if u^d is small enough, we have $\Delta g^* > 0$: a decrease in OAI benefits raises the cutoff level and reduces labor supply. □

A.6 Decreased OAI Benefits in an Economy without DI

Last, consider an economy without DI and repeat the previous experiment.

Proposition 5. *In an economy without DI, a decrease in OAI benefits always increases labor supply, unless the full employment level was achieved.*

Proof. Since the partial derivative of g_0^* with respect to P is positive, a decrease in P lowers g_0^* and raises employment, unless g_0^* was at the minimum. □

The comparison between A.5 and A.6 illustrates that the provision of DI changes the labor supply response towards OAI reforms.

B Dynamic Problem

Employed Individuals

$$
\begin{aligned}
V^e(j,a,g,h,e) = \max_c \{ & u(c, 1-N^e(h)) + \beta s_j(h) E_{\epsilon,j',g',h'|j,g,h}[\sigma I_{j'<J^E} V^o(j',a',g',h',e',0) \\
& + \sigma I_{J^L > j' \geq J^E} \max\{V^o(j',a',g',h',e',0), V^r(j',a',h',b^r(e',j'))\} \\
& + (1-\sigma) I_{j'<J^E} \max\{V^e(j',a',g',h',e'), V^o(j',a',g',h',e',0)\} \\
& + (1-\sigma) I_{J^L > j' \geq J^E} \max\{V^e(j',a',g',h',e'), V^o(j',a',g',h',e',0), V^r(j',a',h',b^r(e',j')\} \\
& + I_{j' \geq J^L} V^r(j',a',h',b^r(e',j')]\}
\end{aligned}
$$

subject to (1), (2), and:

$$
a' = (1-\tau^s)wg + (1 + r(1-\tau^k))k - Q(m(j,h,\epsilon), I_{j \geq J^M}) + x, \tag{13}
$$

$$
e' = f_j(e, wg). \tag{14}
$$

Equation (13) shows the budget constraint. Equation (14) describes the law of motion for the past earning index.

DI Recipients

$$V^d(j,a,h,b^d,i) = \max_c\{u(c,1)+\beta s_j(h)E_{\epsilon,j',h',i'|j,h,i}[I_{j'<J^N}V^d(j',a',h',b^d,i')$$
$$+ I_{j'\geq J^N}V^r(j',a',h',b^d)]\}$$

subject to (1), (2), and the following constraints:

$$a' = b^d + (1+r(1-\tau^k))k - Q(m(j,h,\epsilon),i) + x. \tag{15}$$

OAI Recipients

$$V^r(j,a,h,b^r) = \max_c\{u(c,1)+\beta s_j(h)E_{\epsilon,j',h'|j,h}V^r(j',a',h',b^r)\}$$

subject to (1), (2), and the following constraints:

$$a' = b^r + (1+r(1-\tau^k))k - Q(m(j,h,\epsilon),I_{j\geq J_M}) + x. \tag{16}$$

C Details on Calibration

C.1 Algorithm

A stationary equilibrium is solved using the following six steps.

1. Discretize the state space for the past earning index, benefit levels, and assets by choosing a finite number of grids. The number of grids is 75 for the asset variable and 50 for the other two variables;

2. Guess the values of insurance premiums and lump-sum transfers;

3. Guess a value function for the last age group. Solve the last period individual problem, and iterate on the value function guess until convergence. Derive policy functions;

4. Recursively guess the value functions for other age groups. Solve the individual problems and iterate on the guess until convergence. Derive policy functions;

5. Simulate distribution of individuals using value functions and policy functions obtained in steps 3-4;

6. Update the guess in step 2 and repeat steps 3-5 until convergence.

C.2 Skill Vector and Transition Matrices

The skill vector and transition matrices are displayed as follows:

$$\vec{g} = \begin{bmatrix} 0.100 & 0.111 & 0.144 & 0.200 & 0.278 & 0.378 & 0.500 & 0.644 & 0.811 & 1.000 \end{bmatrix}$$

$$\gamma_1^e(g, g') = \begin{bmatrix} 0.823 & 0.177 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.935 & 0.065 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.949 & 0.051 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.949 & 0.051 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.945 & 0.055 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.939 & 0.061 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.932 & 0.068 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.924 & 0.076 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.916 & 0.084 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 1.000 \end{bmatrix}$$

$$\gamma_2^e(g,g') = \begin{bmatrix} 0.986 & 0.014 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.995 & 0.005 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.996 & 0.004 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.996 & 0.004 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.996 & 0.004 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.995 & 0.005 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.995 & 0.005 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.994 & 0.006 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.993 & 0.007 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 1.000 \end{bmatrix}$$

$$\gamma^o(g,g') = \begin{bmatrix} 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.527 & 0.473 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.229 & 0.771 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.190 & 0.810 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.188 & 0.812 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.199 & 0.801 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.216 & 0.784 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.235 & 0.765 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.257 & 0.743 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.279 & 0.721 \end{bmatrix}$$

The transition matrix for employed individuals aged 60 and above is an identity matrix and not reported.

C.3 Job Separation Rates

Following the method of Elsby et al. (2010) and Shimer (2012), I estimate the age dependent job separation rate from the 2005 December-2006 December CPS. $F_{t,j}$ denotes the outflow probability from unemployment for age group j in month t, and it has the following form:

$$F_{t,j} = 1 - [(U_{t+1,j} - U^{<1}_{t+1,j})/U_{t,j}],$$

where $U_{t,j}$ is the number of unemployed individuals of age group j in month t, $U^{<1}_{t,j}$ is the number of unemployed individuals with unemployment duration less than a month. Note that the second term on the right hand side tells the fraction of people unemployed at time t remaining unemployed after a month. Poisson outflow hazard rate is defined as $f(j) = -\sum_t \log(1 - F_{t,j})/12$.

Under the assumption that hazard rates and labor force are constant across waves, the inflow into unemployment can be expressed as follows:

$$\frac{dU_j}{dt} = x(j)(L_{t,j} - U_{t,j}) - f(j)U_{t,j},$$

where $x(j)$ is the Poisson inflow hazard rate (the flow into unemployment), and $L_{t,j}$ is the size of labor force.

The one month forward solution to the above differential equation is:

$$U_{t+1,j} = (1 - e^{(x(j)+f(j))})U^*_j + e^{(x(j)+f(j))}U_{t,j}, \tag{17}$$

where $(1 - e^{(x(j)+f(j))})$ is the rate of convergence to the steady state, and $U^*_j = \frac{x(j)L_{t,j}}{x(j)+f(j)}$ is the steady state unemployment rate.

Table A1: One Month Unemployment Inflow Hazard Rates

	(1) 20-44	(2) 45-59	(3) 60-64	(4) 65-69
$x(j)$	0.0228***	0.0114***	0.0114***	0.0142***
	(0.00498)	(0.00203)	(0.00118)	(0.00349)
R-squared	0.939	0.971	0.988	0.916

Data are the 2005 December-2006 December CPS. Number of observations is 12. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

By estimating Equation (17), we have the results of Table A1.