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Pension Plan Heterogeneity and Retirement Behavior

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# Pension Plan Heterogeneity and Retirement Behavior\*

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## Abstract

This paper examines the role of the shift in pension plans — from annuity based retirement plans like Defined Benefit to account based plans like Defined Contribution — in explaining the recent increase in labor force participation of older workers. A structural retirement model of consumption, savings, Social Security, and pension plan heterogeneity is estimated using data from the Health and Retirement Study. The model captures key differences in pension wealth evolution across Defined Benefit and Defined Contribution pension plans and produces variation in labor supply, both along the extensive and intensive margins at older ages, as observed in the data. Simulations from the model indicate that changes in pension plan composition can explain 10% to 30% percent of the recent increase in labor force participation of the age group 65 to 69, while changes in Social Security Normal Retirement Age and earnings test can together explain less than a quarter of the increase in labor supply for this group.

**Keywords:** Defined Benefit, Defined Contribution, Social Security, retirement behavior, savings.

**JEL Classification Numbers:** J14, J26, J32, E21, H55.

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# 1 Introduction

An understanding of the determinants of retirement behavior is important both from the point of individual well-being as well as policy making. With nearly 76 million people in the baby boom population (those born between 1946 and 1964) beginning to retire in the U.S., Social Security's projected annual cost is expected to increase to about 6.2 percent of the Gross Domestic Product<sup>1</sup> by 2035, thus posing significant challenges to the U.S. policy makers [(De Nardi et al., 1999), (Galasso, 2008), (Bohn, 1999)]. This has fueled an interest in research geared towards understanding the determinants of retirement. Past research has shown that pension wealth is crucial in governing retirement decisions [(Stock and Wise, 1988), (Kotlikoff and Wise, 1987), (Kotlikoff and Wise, 1989), (Samwick, 1998), (Chan and Stevens, 2004)]. In the last few decades however, the pension landscape in the U.S. has undergone a major overhaul. From being once dominated by the traditional annuity-based Defined Benefit (DB) plans, the trend has now moved towards account-based Defined Contribution (DC) plans. This change has been accompanied by a reversal in the participation trend of older men resulting in an increasing labor force participation of the elderly in the United States, over the last thirty years.

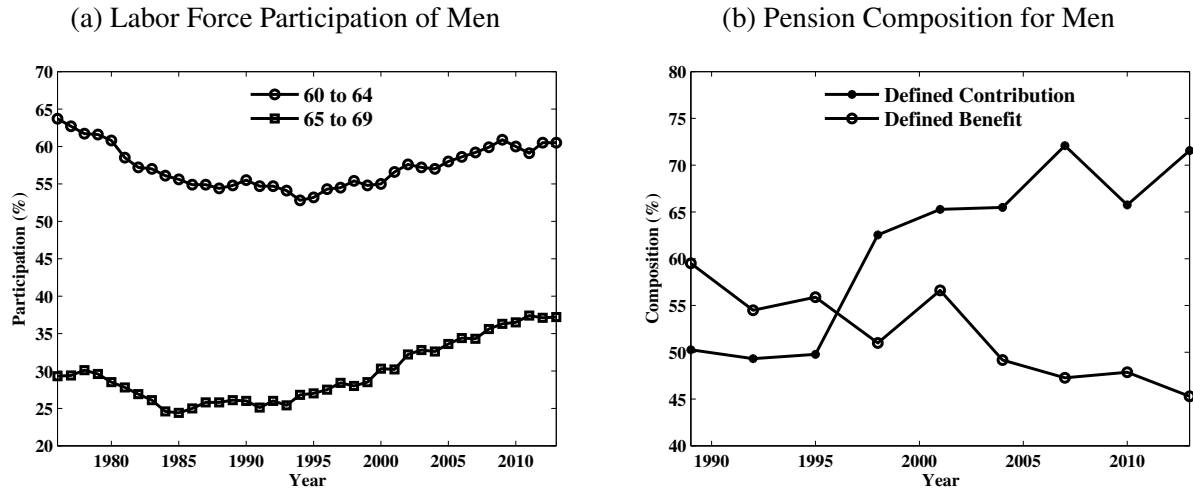
The declining trend of participation of older men ended in the late 1980s and the labor force participation increased for certain age groups. For instance, between 1990 and 2010, the participation rates for the age group 60-64 increased by 8% (roughly), while it increased by 40% for those in between ages 65 and 69 (see figure 1a). The pension plan composition also changed during the same time. Pension coverage by Defined Benefit plans declined from 60% in 1989 to 48% in 2010 while it increased from 50% to 65.7% for Defined Contribution plans (see figure 1b).

Importantly these changes have not been confined to the United States alone. Broadbent et al. (2006) find empirical evidence that indicates a shift from the traditional Defined Benefit to Defined Contribution plans for several other OECD countries like Canada, Australia and U.K. The striking observation is that these countries also underwent a reversal in the trend of declining labor force participation of the older workers around the same time as the change in pension landscape (see

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<sup>1</sup>Figure taken from 2013 Social Security Annual Report (Social Security and Medicare Boards of Trustees).

Figure 1: Labor Force Participation Trend and Pension Plan Composition



*Data Source:* Bureau of Labor Statistics (left), Survey of Consumer Finances (right). Pension plan composition is based on fraction of male household heads (ages 50 to 60) reporting a particular pension type conditional on having some pension.

figure 2).

The change in retirement behavior of older workers could also be attributed to a host of other changes that have taken place in the economy like changes in Social Security rules, improvements in health and life expectancy at older ages, changes in skill composition of the workforce etc. (see Quinn (2002); Maestas and Zissimopoulos (2010) for a comprehensive report). This study explores the role played by changes in retirement wealth, primarily due to changes in pension composition.

To this end, a life cycle model of retirement, savings, and heterogeneity in pension wealth accrual for older men is estimated using data from the Health and Retirement Study. The key details of the two pension plans – DB and DC are built into a dynamic programming model of retirement which generates differences in pension wealth accumulation patterns. This in turn generates the differences in retirement behavior in the model as observed in the data. Hence the model developed in this paper produces rich variations in labor supply across different pension groups without resorting to any kind of unobserved heterogeneity in preferences. The estimated model is used to simulate the effect of pension plan phase out from DB to DC on labor supply of older workers. The results are then compared to two important Social Security policy changes that have taken place in

the recent times — 1) increase in Normal Retirement Age (NRA) and 2) removal of earnings test for certain age groups.

The quantitative exercise conducted in this paper provides several interesting insights. First, the paper finds that heterogeneity in pension wealth evolution is crucial in pinning down systematic differences in labor force participation rates observed across different pension groups. Second, counterfactual simulations indicate that a 50% change from DB to DC plans results in a 12% increase in the participation of the age group 65 to 69, and a 4% increase for the group 60-64. In comparison, increasing the Social Security NRA by a year and removing the earnings test for those past the NRA results in a 4% (roughly) increase (in each case) in participation for the age-group 65-69. This implies that pension composition changes can explain anywhere between a tenth to a third of the increase in participation of the age-group 65 to 59 (for pension composition changes between 20% to 50%), while the two Social Security policy changes together can explain roughly 20% of the increase in participation. Finally, counterfactual experiments reveal that individuals with different pension plans respond differently to changes in Social Security rules. For instance, increase in NRA has the strongest effect on the labor supply of those without any pensions and the smallest on those with Defined Benefit pensions. Removal of earnings test also results in very different intensive and extensive margin responses by individuals in different pension groups. The results thus indicate that modeling pension plan heterogeneity is not only crucial for understanding the effects of changes in pension composition on older workers' labor supply, but also for understanding the aggregate retirement behavior of older workers itself as well as the effect of any policy changes on it.

The paper contributes to several existing strands of literature. First, it adds to a growing body of evidence on the recent changes in the retirement behavior of the elderly and its potential drivers. Previously, two empirical studies Blau and Goodstein (2010); Friedberg and Webb (2005) have investigated the contribution of Social Security policy changes and pension composition respectively, in explaining the reversal of the labor force participation trends of the elderly. The usefulness of the structural framework here is that it allows for individuals to dynamically re-optimize in the

event of a change. Empirical studies not allowing for intertemporal substitution may overestimate the effect of any policy changes. However, the effect of these changes might be exacerbated by the presence of uninsurable life-cycle risks. If so, studies not accounting for these risks may greatly underestimate effect sizes.

Second, it adds to the existing structural models of retirement which can be broadly classified into three groups with respect to modeling pension wealth. The first is a class of models having pension wealth accrual through a single kind of pension plan which combines features of both Defined Benefit and Defined Contribution (French, 2005), (French and Jones, 2011), (Blau and Gilleskie, 2008). The models in these papers cannot generate the different retirement patterns across different pension plan types and hence, are not suited for understanding the effect of changing pension plan composition on retirement behavior. For instance, the pension benefits in (Blau and Gilleskie, 2008) depend on an individual's age, experience and employment status which closely resembles the Defined Benefit plan structure. This benefit formula is not a good approximation for wealth under a Defined Contribution plan for two reasons. First, DB benefits are distributed as an annuity whereas DC wealth is distributed as a onetime lump sum transfer to a non-pension account. Second, this formula is unable capture the most important difference between the two plans – DB pension wealth declines sharply after a certain age incentivizing exit from the labor market whereas the returns to staying with the provider for an additional year stays the same for DC plan holders. This is key to explaining the difference in retirement behavior observed for people on these two different pension plans. For this reason, the pension benefits in this paper for DB and DC plans are calculated using the precise rules of these plans taken from the restricted pension plan data provided directly by the employers for all individuals in the estimation sample.

The second group of papers abstract away from modeling pension wealth accrual (Casanova, 2010), (Van der Klaauw and Wolpin, 2008), (Rust and Phelan, 1997). The models in these papers miss a key source of variation in retirement behavior. In the third group, (Blau, 2011) is the only paper to the best of my knowledge that models pension wealth accumulation through both

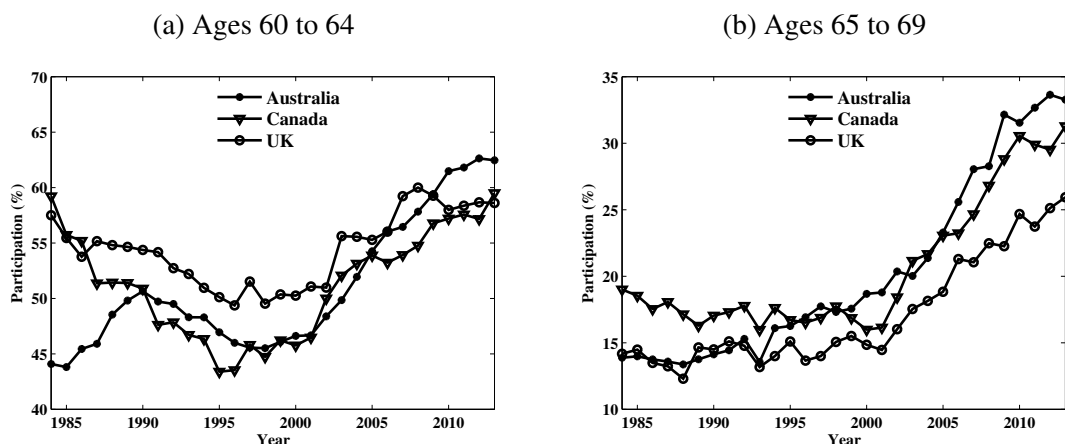
Defined Benefit and Defined Contribution plans for understanding the effect of pension wealth in crowding out private savings. The model in this paper adds to this work by introducing intensive margin of labor supply, health shocks affecting labor productivity, mortality, and time endowment and capturing all the major work disincentives provided by the Social Security rules. Introducing the choice of hours worked in a retirement model generates a new margin of adjustment for the agents. This is especially important for understanding the effect of policies like Social Security earnings test which targets earnings and not participation. Health is shown to be an important determinant of retirement (Dwyer and Mitchell, 1999), (Sickles and Taubman, 1984). The health shocks in the model are crucial for generating reduction in hours worked and non-participation especially for those without any pension plan. Both pensions and Social Security provide major work disincentives at older ages. Hence it is important to model these two programs accurately in order to disentangle the effect of each on labor supply.

The rest of the paper is organized as follows. The next section provides some background information on pension plans in the U.S.. Section (3) develops the dynamic programming model of pension, savings, and retirement. Section (4) describes the data and calibration exercise. In section (5), estimation and model simulation results are presented. Section (6) provides some insights on the importance of modeling pension heterogeneity. Finally concluding remarks are offered in section (7).

## **2 Background**

The first private pension was established in the United States as early as 1875 by the American Express Company. While these pensions were completely private and unregulated, a series of laws passed under the Revenue Act affected the federal tax treatment of these plans. There was a rapid growth of pension coverage attributed to employers' desire to reduce labor turnover and replace older, less productive employees. In addition, the 1926 Revenue Act exempted income of pension trusts from current taxation. This tax advantage provided additional incentive for firms to provide

Figure 2: Labor Force Participation of Men



Data Source: OECD database

pensions. By 1930, a majority of large firms had adopted pension plans, covering about 20 percent of all industrial workers Short (2002). The Employment Retirement Income Security Act (ERISA), passed in 1974 regulated private pensions to ensure their solvency. While ERISA did not require firms to provide pension benefits, it played a critical role in structuring the plans of the employers who chose to do so Penner et al. (2002). Traditionally pensions were Defined Benefit in nature where the employer controlled the contribution formula and the investment decisions and very few deferred compensation arrangements or Defined Contribution plans existed. However, the Revenue Act of 1978 for the first time, laid down rules regarding the tax treatment of Defined Contribution plans where employees could make tax-deferred contributions to a retirement account.

Defined contribution plans soon gained popularity among firms as they shifted the risk of poor investment performance from the employer to the employee. A host of other factors like increased workforce mobility associated with demographic and industrial change, increased cost of DB pensions due to increased longevity and so on could have also been potential accelerators in the shift from Defined Benefit to Defined Contribution plans (see Gustman et al. (2010) for a detailed discussion).

The following sections now discuss the important source of variation in pension wealth evolution and work disincentives across Defined Benefit and Defined Contribution pension plans. Using



the biennial panel data from the Health and Retirement Study (see section 4 for details), I first describe the pension wealth evolution for an average DB and DC plan and then look at labor market transitions for different pension groups — DB, DC and NO (those without any pension plans).

## 2.1 Pension Wealth

The two types of pension plans – Defined Benefit and Defined Contribution – have different wealth accrual patterns over the life cycle of an individual. The benefits in a defined benefit plan are based on tenure and earnings in the final years of service with the pension provider. As a result, pension wealth in a DB plan accrues non-linearly with age, the benefit increase being the greatest from working the years close to the eligibility for *normal retirement*<sup>2</sup> benefits and declines sharply after. This nature of wealth accrual in a DB plan has two important implications for labor market outcomes of the elderly - first, the present discounted value of pension benefits accruing from a DB plan decreases by staying with the employer longer than a certain age, providing a strong incentive to exit the labor market right after reaching the full potential of the pension plan (Normal Retirement Age). Secondly it is expensive to cut work hours close to years before retirement as it affects the entire stream of benefits to be received after retirement. Pension wealth in a DC plan, on the other hand, is the market value of the current assets accumulated in a portable account, resulting in an age independent profile of pension wealth accrual. An additional year of work increases pension wealth by the same amount at any point in the life cycle and a reduction in hours reduces pension wealth only in the year in which reduced earnings are observed.

Table 1 gives the present discounted value of accrued pension benefits (PV) and marginal change in PV for both Defined Benefit and Defined Contribution plans as observed in the HRS data<sup>3</sup>.

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<sup>2</sup>This is not the same as the Social Security Normal Retirement Age (NRA). Under DB plans, NRA simply refers to the age at which a DB pension plan holder is eligible to receive full accrued benefits. This is usually set by the plan/employer. Usually 60, 62, and 65 are the most common NRA's for DB pensions.

<sup>3</sup>Pension Estimation Software provided with the HRS restricted pension data is used to calculate average pension wealth in a DB and DC plan for specific quite dates for the HRS cohort. For DB pension plans, individuals with an NRA of 65 are only considered in this example

Table 1: Present Value of Accrued Benefits and Marginal Change in Benefits

Current Age	Defined Benefit			Defined Contribution		
	PV	Marginal Change in PV		PV	Marginal Change in PV	
	1998 \$	1998 \$	% Earnings	1998 \$	1998 \$	% Earnings
63	72,362	15,35	3.0	85,664	1,569	2.8
64	73,638	12,76	2.4	87,305	1,641	2.8
65	78,265	4,626	8.3	88759	1,453	2.4
66	77,322	-942	-1.6	89,985	1,225	2.0
67	75,933	-1,389	-2.3	90,959	973	1.4
68	74,364	-1,568	-2.4	91,743	783	1.1

Notes: PV refers to present discounted value of accrued benefits.

Most of the pension wealth in a DB plan accrues from working the year before the NRA of the plan and falls right after as shown in columns 3 and 4 of the table. For instance, individuals accrue pension wealth worth 8% of their labor earnings by working at age 64 and lose upto \$1500 in pension wealth by working past the NRA Individuals in Defined Contribution plans on the other hand experience a steady 1% to 3% increase in pension wealth by continuing work at older ages.

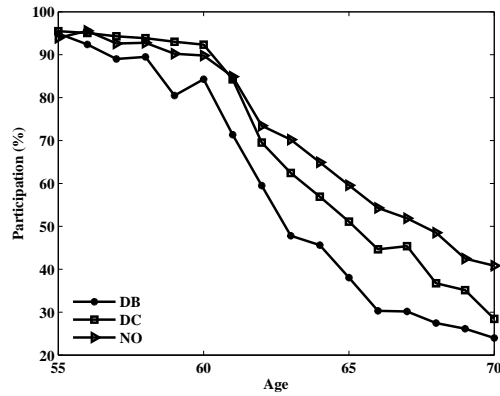
## 2.2 Retirement Behavior

I now present empirical evidence of differences in retirement behavior across different pension plan holders. Figure (3a) shows that participation rates decline over the life cycle for all three pension groups but the labor force participation for DC and NO pension groups remain systematically higher than DB pension holders. For instance, labor force participation rates at age 65 for DB pension holders remain 15% lower than DC pension holders and 32% lower than those without any pension plans.

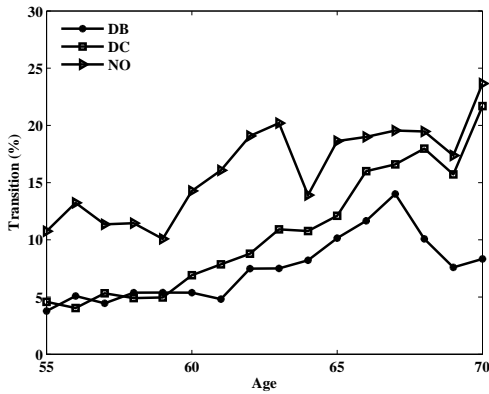
Figures (3b and 3c) show the labor force transitions for these three groups from full-time work

to part-time and retirement<sup>4</sup> respectively. These figures indicate that DB pension holders are most likely to move into retirement directly from full-time jobs and DC pension holders switch into retirement more gradually by taking some part-time job. This further shows that DB pension holders face the strongest incentives to leave the labor market upon becoming eligible for pension benefits.

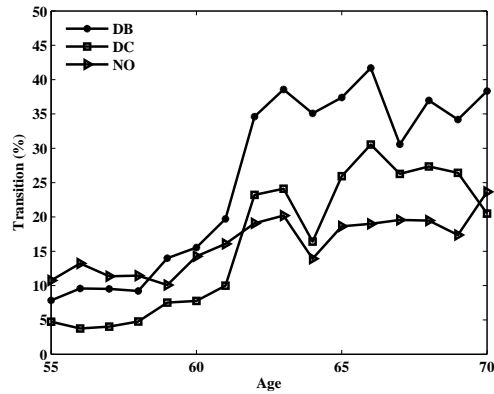
Figure 3: Retirement Behavior for Men by Pension Plan Type



(a) Participation



(b) Full-Time to Part-Time (F-P)



(c) Full-Time to Retirement (F-R)

Note: Two year transition probabilities are reported. F-P refers to the probability of going from full-time in period  $t$  to part-time in period  $t + 2$ . F-R refers to the probability of going from full-time in period  $t$  to retirement in period  $t + 2$ .

<sup>4</sup>Full-time is defined as working more than 1750 hours annually and part-time is working less than full-time and more than 300 annual hours. Retirement is non-participation/working zero hours

### 3 Model

This section presents a dynamic programming model of retirement, Social Security, and private pensions. In order to capture the true nature of retirement incentives for older workers, retirement benefits from private pension programs and Social Security are modeled in great detail to match that of the current U.S. system.

Labor supply ( $h_t$ ), consumption ( $c_t$ ), Social Security benefit application, ( $b_t^{ss}$ ) and pension claiming decisions ( $b_t^{pen}, pen \in \{db, dc\}$ ) of a male household head is modeled close to the years before retirement. Individuals make these decisions in every time period  $t$  and adjust their behavior in response to uncertainty pertaining to wages, health, survival, and rate of return on pension wealth.

At the beginning of every time period (age)  $t$ ,  $t = 55, 56, \dots, 95$ , individuals observe their permanent pension type ( $pen \in \{db, dc, no\}$ )<sup>5</sup>, pension wealth ( $q_t^{pen} \text{ } pen \in \{db, dc\}$ ), non-pension wealth ( $a_t$ ), Social Security wealth ( $e_t$ ), wage ( $w_t$ ), health status ( $m_t \in \{good, bad\}$ ), Social Security and pension claiming status ( $b_{t-1}^{ss}, b_{t-1}^{db}, b_{t-1}^{dc}$ ), employment status ( $\lambda_t$ ), pension eligibility ( $\varphi_t$ ), and tenure with the pension provider ( $ten_t$ )<sup>6</sup>. Given this vector of states, individuals choose optimal consumption, labor supply and make Social Security benefit application and pension claiming decisions (if eligible) to maximize the present discounted value of life-time utility. The dynamic programming model has various components. The following sections describe each key ingredient in detail.

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<sup>5</sup>Throughout the paper, the lower case *db* or *dc* would signify actual model states, whereas uppercase DB or DC would refer to the respective plan in general.

<sup>6</sup>The last two state variables are only relevant for the DB pension type in the model.

### 3.1 Preferences

Agents in period  $t$  derive utility from consumption  $c_t$  and leisure  $l_t$ . The within period utility is non-separable<sup>7</sup> between consumption and leisure and is given by:

$$U(c_t, l_t) = \frac{1}{1 - \rho} (c_t^\nu l_t^{1-\nu})^{(1-\rho)}$$

Where  $\rho$  is the coefficient of relative risk aversion and  $\nu$  is the weight on consumption. The total amount of leisure in period  $t$  is given by:

$$l_t = \bar{l} - h_t - \phi_P I\{h_t > 0\} - \phi_H I\{m_t = \text{bad}\} \quad (1)$$

Where  $\bar{l}$  is the total endowment of leisure each period,  $h_t$  is hours worked,  $\phi_H$  is the amount of leisure lost due to a bad health shock and  $\phi_P$  is participation cost incurred if hours worked  $h_t$  are positive. Upon dying an individual values bequests of any leftover assets  $a_t$  according to the utility function developed by De Nardi (2004)

$$b(a_t) = \frac{\theta_{beq}}{1 - \rho} (a_t + \kappa_{beq})^{(1-\rho)\nu}$$

The coefficient  $\theta_{beq}$  measures the strength of bequest motive and  $\kappa_{beq}$  measures the curvature of bequest function. Increase in  $\theta_{beq}$  increases the marginal utility of a unit of bequest and increase in  $\kappa_{beq}$  indicate that the bequest is valued more like a luxury good.

### 3.2 Health and Mortality

Every period individuals are subject to an exogenous health shock which can take two values  $m_t \in \{good, bad\}$ . Bad health affects individuals in multiple ways – it lowers the survival prob-

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<sup>7</sup>The paper follows (French and Jones, 2011), (French, 2005), (Casanova, 2010) and others in addressing the "Retirement-Consumption puzzle". A decline in consumption at retirement is caused by both- 1) unexpected health shocks to leisure causing unplanned retirement and 2) non-separability of preferences between consumption and leisure.

ability for the next period, lowers the wages and affects the amount of leisure consumed. The transition probability for health depends on current health status and age in the next period. A typical element in the health transition matrix is given by:

$$\pi_{good,bad,t+1}^m = prob(m_{t+1} = good | m_t = bad, t + 1)$$

Individuals are also subject to mortality shocks in each period. The survival probability for the next period depends on age next period and current health status:

$$\pi_{t+1}^s = prob(s_{t+1} = 1 | m_t, t + 1)$$

### 3.3 Wages

Hourly wage in every time period is a function of an age and health specific profile  $\omega^{pen}(m_t, age_t)$  for each pension type, and an autoregressive component  $\eta_t$ .

$$\begin{aligned} \log w_t &= \omega^{pen}(m_t, t) + \eta_t \\ \eta_t &= \rho_w \eta_{t-1} + \epsilon_t^w \\ \epsilon_t^w &\sim N(0, \sigma_{\epsilon^w}^2) \end{aligned} \tag{2}$$

### 3.4 Social Security

The Social Security system in the U.S. provides retirement incentives at the time when these benefits become available. The benefits are computed in several steps. First the earnings of the 35 highest earning years are averaged into an index — Average Indexed Monthly Earnings (AIME). The AIME increases by working an additional year if earnings in that year is higher than the lowest earnings embedded in it and is also capped at some threshold. Let  $e_t$  be the Social Security wealth in the model (annualized measure of AIME <sup>8</sup>). Then the Social Security wealth evolution is

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<sup>8</sup>Please refer to appendix A for more details

approximated in the model in the following simple way:

$$e_{t+1} = \max\{(e_t + \max\{0, (w_t h_t - e_t)/35\}), e^{\max}\} \quad (3)$$

Where  $e^{\max}$  is the threshold at which AIME is capped. This index is then converted to obtain the Primary Insurance Amount (PIA) which determines the Social Security benefits. The Social Security benefits are a piece-wise linear function of Social Security wealth. It is computed in the following way in the model (using the exact rules from the Social Security Administration (SSA)):

$$ssb_t = \kappa_t \left[ 0.90 \times \min\{e_t, b_0\} + 0.32 \times \min\{\max\{e_t - b_0, 0\}, b_1 - b_0\} + 0.15 \times \max\{e_t - b_1, 0\} \right] \quad (4)$$

The Social Security system provides several work disincentives at older ages. First, AIME is only recomputed upwards if current earnings are greater than previous year of work. For instance, staying longer in the labor market by working part-time does not increase the benefits. Secondly, these benefits can be claimed without any penalty at the Normal Retirement Age (NRA) which is typically around age 65<sup>9</sup>. However, individuals can claim benefits as early as the Early Retirement Age (ERA) which is age 62, with some penalty. For every year before the NRA that these benefits are claimed, the Social Security amount received by an individual is permanently reduced by a certain fraction. Individuals can also delay their benefit claim beyond NRA. In that case, future benefits are permanently increased by a certain amount. It has been largely argued in the literature (Heiland and Yin, 2014; Gruber and Wise, 2005) that while the benefit reductions due to early claim are actuarially fair, the delayed claim benefit increase does not fully compensate the beneficiary for the loss in benefits in the previous periods, hence, are not actuarially fair. This structure of the Social Security system thus provides strong incentives to claim benefits at the earliest possible.

Finally the Social Security earnings test taxes the labor income (above a certain threshold) of

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<sup>9</sup>The NRA is slightly different for different birth cohorts. For instance, the sample used in this analysis, observed an average NRA of 65. But later cohorts observed an NRA of 66 or 67.

the Social Security beneficiaries at a very high rate, till the age of 70. The earnings test combined with the benefit application age structure may provide incentives to retire upon reaching the claiming age.

All these features are captured in detail in the model. Since the Social Security rules have been changing over time, the specific rules pertinent to the sample used in this analysis are used from SSA. Please refer to Section 4.2 and appendix A for details.

### **3.5 Pensions**

Like Social Security, private pensions provide important retirement incentives. There are mainly two important types of pension plans in the U.S. — Defined Benefit (DB) and Defined Contribution (DC)<sup>10</sup>. While these plans are highly complex in design and heterogeneous across individuals working with different employers, the two types of plans, DB and DC systematically differ along some key dimensions as discussed earlier. The paper makes several simplifying assumptions in modeling these plans, yet captures the salient sources of heterogeneity across these plans which are indispensable for accurately predicting retirement behavior.

#### **Defined Benefit (DB)**

DB plans pay a sequence of benefits computed using a predefined formula commencing upon reaching NRA of the plan until death. In the computation of DB benefits, there are two important sources of heterogeneity which are important. First, different individuals face different NRA for their pension plan. And the second arising from the benefit computation formula itself – benefits typically depend on tenure with the pension provider and the average of the five highest earnings (last 5 years of service) at the firm.

The model captures both these sources of heterogeneity. First, eligibility in the model is determined as a function of age and tenure with the pension provider. Conditional on being eligible,

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<sup>10</sup>There are also hybrid plans like such as cash balance plans, and money purchase pension plans, which are defined contribution plans with a predefined contribution formula.



benefits are determined as a function of tenure and the Social Security pension wealth<sup>11</sup>.

Unlike Social Security, pension claiming decisions are usually tied to employment decisions in a DB plan. In-service distributions are not allowed under DB plans i.e. a worker has to quit the job with the pension provider (retire or work with a new employer) to start drawing benefits from the pension plan<sup>12</sup>. Following this, individuals in the model can also receive these benefits (if eligible) only by either quitting work or switching jobs. The latter option is usually accompanied by either taking part-time work or switching to a low paying job. In the model, this loss in productivity is captured through a time cost  $\chi$  in equation 1. More specifically, to claim pension benefits, individuals can either quit work or continue working with a reduced time endowment in all subsequent periods of work as shown below.

$$l_t = \bar{l} - h_t - \phi_P I\{h_t > 0\} - \phi_H I\{m_t = \text{bad}\} - \chi \quad (5)$$

### **Defined Contribution (DC)**

Pension wealth under a DC plan is characterized by an account balance with employer and worker contribution rates. As long as the individual works for the DC pension provider, both the employer and the employee contribute a fixed fraction of the employee's pre-tax labor earnings to the account. The stochastic rate of return on assets in this account captures the risk that the worker bears as opposed to benefits in a DB plans which has no risk.

Individuals in the model can claim their DC wealth after a certain age<sup>13</sup>. In practice, these claiming decisions can be complex where individuals can choose to claim benefits and roll over the funds into a tax-sheltered Individual Retirement Account (IRA) or transfer the money to the

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<sup>11</sup>The wage base used for computing benefits is provided with the restricted pension data. However, I approximate benefits as a function of AIME (which is also an index of highest earning years) for reducing the computational burden.

<sup>12</sup>Under the Internal Revenue Code and ERISA, a defined benefit plan could only permit a distribution of benefits at termination of employment, retirement, termination of the plan or total and permanent disability of the participant. Later in 2006 some of these restrictions were relaxed. The Pension Protection Act of 2006 (PPA) and its finalization in 2007 (the "Final PPA Regulations") provided rules permitting distributions from DB plans upon reaching NRA and after age 62. But since most of the individuals in my estimation sample are older than 70 in 2006, these laws do not affect them.

<sup>13</sup>In practice there is a penalty for claiming the DC account balance before age  $59\frac{1}{2}$ . In the model, the DC wealth is illiquid until age 60.

new employer's plan. However, in the model, for computational simplicity, the claiming decision entails a one-time transfer of the DC pension wealth to the non-pension wealth account which incurs a risk free rate of return ( $r$ ) and can be used towards consumption.

The pension claiming decision for a DC pension plan holder is distinct from employment decision as opposed to an individual with a DB plan. Once eligible (after age 60), DC plan holders can choose any of the four options. First, they can claim their pension and continue working (accrue no further pension in that case). Second, they can continue working and keep accruing pension benefits through both their contributions and employer contributions to the pension account. Additional pensions are also accrued through stock market returns on these investments. Third, individuals can choose not to work and not claim pensions. In this case, they don't accrue any further pensions through employer contributions but still may accrue pensions through stock market returns. Finally, individuals can choose to claim benefits after retirement from the labor market.

The evolution of DC wealth in the model is as follows:

$$q_{t+1}^{dc} = \begin{cases} [q_t^{dc} + (cr_w + cr_e)w_t h_t](1 + r_{t+1}) & \text{if } b_t^{dc} = 0 \text{ \& } h_t > 0 \\ q_t^{dc}(1 + r_{t+1}) & \text{if } b_t^{dc} = 0 \text{ \& } h_t = 0 \end{cases} \quad (6)$$

Where  $b_t^{dc}$  is the DC pension claiming decision,  $cr_w$  and  $cr_e$  are the contributions made by the worker and the employer respectively to the DC account. Finally  $r_t$  is a stochastic rate of return on the balances in a DC account given by a mean reverting stochastic process (Blau, 2011).

$$1 + r_t = (1 + \bar{r}) \exp\{\psi_t\}$$

Where  $\bar{r}$  is the mean rate of return and  $\psi_t \sim N(0, \sigma_\psi^2)$  is an iid (over time and across individuals) normal shock. The stochastic rate of return on DC balances captures the key difference in uncertainty between the two types of pension plans. The rate of return heterogeneity also captures the heterogeneity in portfolio allocation choice which is not modeled here.

### 3.6 Budget Constraint

An individual's income consists of various components. He receives income through hours worked in the labor market  $w_t h_t$ , spousal income  $y_{st}$ , interest on assets  $ra_t$ , pension benefits  $pb_t^{db}$  from Defined Benefit plan, Social Security benefits  $ss_t$  (if applied for it) and government transfers  $tr_t$  if eligible.

Let  $y(\cdot, \tau)$  be the level of post-tax income, then the asset accumulation equation for each of the three pension type  $pen \in \{db, dc, no\}$  is given by:

$$a_{t+1} = \begin{cases} a_t + y(w_t h_t, y_{st}, ra_t, pb_t^{db}, \tau) + b_t^{ss} \times ssb_t + tr_t - c_t & \text{if } pen = db \\ a_t + y((1 - cr_w)w_t h_t, y_{st}, ra_t, \tau) + b_t^{ss} \times ssb_t + tr_t - c_t & \text{if } pen = dc \\ a_t + y(w_t h_t, y_{st}, ra_t, \tau) + b_t^{ss} \times ssb_t + tr_t - c_t & \text{if } pen = no \end{cases} \quad (7)$$

There is a borrowing constraint on non-pension assets given by:

$$a_{t+1} \geq 0 \quad \forall t \quad (8)$$

and a consumption floor which guarantees a minimum level of consumption (Hubbard et al., 1995).

$$c_t \geq \bar{c} \quad (9)$$

Government transfers  $tr_t$  bridge the gap between this minimum level of consumption and individual's liquid resources<sup>14</sup>.

$$tr_t = \min\{0, \bar{c} - (a_t + y_t + ss_t)\} \quad (10)$$

---

<sup>14</sup>This is a simple approximation to the federal safety net programs in the U.S. like Supplemental Nutritional Assistance Program (SNAP), Supplemental Security Income (SSI), Temporary Assistance for Needy Families (TANF) etc.

### 3.7 Recursive Formulation

Let  $\mathbf{x}_t = (a_t, e_t, w_t, q_t^{pen}, \lambda_t, ten_t, m_t, b_{t-1}^{ss}, b_{t-1}^{pen})$  be the period  $t$  state vector for each pension type  $pen$ . Then individuals solve a finite-horizon Markovian decision problem where they choose a sequence of consumption  $\{c(\mathbf{x}_t)\}_{t=1}^T$ , hours  $\{h(\mathbf{x}_t)\}_{t=1}^T$ , Social Security benefit application  $\{b^{ss}(\mathbf{x}_t)\}_{t=1}^T$  and pension claiming  $\{b^{pen}(\mathbf{x}_t), pen \in \{db, dc\}\}_{t=1}^T$  rules to maximize the expected discounted lifetime utility subject to the exogenous processes for health transition, survival, rate of return on pension wealth, and wage determination, a set of budget (7), borrowing (8), and time constraints (1), government transfer rule (10), private pension wealth accrual and policies for taxes and Social Security.

For each pension type, the life-cycle of an individual between ages 55 and 95 is divided into two distinct phases. The first is the *transition* phase between ages 55 and 70, marked by consumption, hours, Social Security and pension claiming decisions. This is the period when individuals transition from work to retirement and face differential retirement incentives based on the type of pension plan. The second phase is the *complete retirement* phase where individuals only make consumption decisions<sup>15</sup>. While all three pension types — *db*, *dc*, *no* solve a similar problem in the second phase, their value function (solution to a bellman equation) and decision problem are significantly different from each other in the *transition* phase. For exposition purposes, the bellman equation for each pension type in each phase has been written separately.

#### No Pension

Individuals without any pension plan choose consumption, hours, and make Social Security application decisions if eligible (between ages 62 and 70). Their decision problem in the *transition*

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<sup>15</sup>This is to simplify computational burden but it poses no serious constraint to the analysis. Social Security rules provide no incentive to delay benefit claims beyond age 70, as a result of which most claiming decisions happen between ages 62 and 70. Most pension plans also provide strong incentives to claim between ages 55 and 70. In some cases individuals may choose to work beyond age 70 and accrue pension wealth in a Defined Contribution account. However, labor force participation beyond 70 is rare in the sample analyzed in this paper.

phase is given as follows:

$$\begin{aligned}
V^{no}(a_t, e_t, w_t, m_t, b_{t-1}^{ss}) = \max_{\{c_t, h_t, b_t^{ss}\}} & \left\{ U(c_t, l_t) \right. \\
& + \beta \pi_{t+1}^s \left[ \pi_{bad|m_t}^m \int V^{no}(a_{t+1}, e_{t+1}, w_{t+1}, m_{t+1}, b_t^{ss}) f(w_{t+1}|w_t) dw \right. \\
& + \left. \left. (1 - \pi_{bad|m_t}^m) \int V^{no}(a_{t+1}, e_{t+1}, w_{t+1}, m_{t+1}, b_t^{ss}) f(w_{t+1}|w_t) dw \right] \right. \\
& \left. + \beta(1 - \pi_{t+1}^s) b(a_{t+1}) \right\} \quad s.t.
\end{aligned}$$

$$a_{t+1} = a_t + y(w_t h_t, y_{st}, \bar{r} a_t, \tau) + b_t^{ss} \times ssb_t + tr_t - c_t,$$

(1), (8), and (9).

The decision problem in the *complete retirement* phase is given by:

$$\begin{aligned}
V^{no}(a_t, e_t, m_t) = \max_{c_t} & \left\{ U(c_t, l_t) + \beta \pi_{t+1}^s \left[ \pi_{bad|m_t}^m V^{no}(a_{t+1}, e_{t+1}, m_{t+1}) \right. \right. \\
& \left. \left. + (1 - \pi_{bad|m_t}^m) V^{no}(a_{t+1}, e_{t+1}, m_{t+1}) \right] \right. \\
& \left. + \beta(1 - \pi_{t+1}^s) b(a_{t+1}) \right\} \quad s.t.
\end{aligned}$$

$$a_{t+1} = a_t + y(y_{st}, \bar{r} a_t, \tau) + ssb_t + tr_t - c_t,$$

(1), (8), and (9).

## Defined Benefit Pension

Individuals who have Defined Benefit plans also make DB pension claiming decisions (if eligible) in addition to those made by *no* pension type.

Pension claiming decision  $b_t^{db}$  is tied to the labor supply decision for a *db* type as explained earlier. If eligible for pensions ( $\varphi_t = 1$ ), individuals can receive benefits by quitting work ( $h_t = 0$ ) or working for a different employer ( $\lambda_t = 0$ ), undergoing a productivity loss through reduction in work time endowment  $\chi$  as given in equation 5. Individuals can also choose to continue working

with the pension provider ( $\lambda_t = 1$ ) and delay benefit claim. If not eligible for pension, individuals have no incentive to switch employers. Once individuals quit working with their pension provider ( $\lambda_t = 0$ ) by either quitting work or switching to a different employer, they cannot go back to working with their pension provider. For computational simplicity, the model assumes that new jobs do not provide any pension benefits.

Let  $\mathbf{x}_t = (a_t, e_t, w_t, \varphi_t, \lambda_t, ten_t, m_t, b_{t-1}^{ss}, b_{t-1}^{db})$  be the period  $t$  state vector for a  $db$  type. Then the decision problem in the *transition* phase is given as follows:

$$\begin{aligned}
V^{db}(\mathbf{x}_t) = \max_{\{c_t, h_t, b_t^{ss}, b_t^{db}\}} & \left\{ U(c_t, l_t) \right. \\
& + \beta \pi_{t+1}^s \left[ \pi_{bad|m_t}^m \int V^{db}(\mathbf{x}_{t+1}) f(w_{t+1}|w_t) dw \right. \\
& \left. \left. + (1 - \pi_{bad|m_t}^m) \int V^{db}(\mathbf{x}_{t+1}) f(w_{t+1}|w_t) dw \right] \right. \\
& \left. + \beta(1 - \pi_{t+1}^s) b(a_{t+1}) \right\} \quad s.t.
\end{aligned}$$

$$a_{t+1} = a_t + y(w_t h_t, y_{st}, \bar{r} a_t, b_t^{db} \times pb_t^{db}, \tau) + b_t^{ss} \times ssb_t + tr_t - c_t,$$

(1), (8), and (9).

The decision problem in the *complete retirement* phase is given by:

$$\begin{aligned}
V^{db}(a_t, e_t, ten_{70}, m_t) = \max_{c_t} & \left\{ U(c_t, l_t) + \beta \pi_{t+1}^s \left[ \pi_{bad|m_t}^m V^{db}(a_{t+1}, e_{t+1}, ten_{70}, m_{t+1}) \right. \right. \\
& \left. \left. + (1 - \pi_{bad|m_t}^m) V^{db}(a_{t+1}, e_{t+1}, ten_{70}, m_{t+1}) \right] \right. \\
& \left. + \beta(1 - \pi_{t+1}^s) b(a_{t+1}) \right\} \quad s.t.
\end{aligned}$$

$$a_{t+1} = a_t + y(y_{st}, \bar{r} a_t, pb_t^{db}, \tau) + ssb_t + tr_t - c_t,$$

(1), (8), and (9).

## Defined Contribution Pension

The pension claiming decision for a *dc* type is independent from labor supply decisions. Individuals after reaching the DC pension claiming age (60) can continue working for their pension provider, having claimed or not claimed the DC pension account. Pension wealth is accrued through employer and worker contributions to the DC account as well as stock market returns on the investments as long as the individual is working. Let  $\mathbf{x}_t = (a_t, e_t, w_t, q_t^{dc}, m_t, b_{t-1}^{ss}, b_{t-1}^{dc})$  be the period  $t$  state vector for a *dc* type. Then the decision problem in the *transition* phase is given as follows:

$$\begin{aligned}
 V^{dc}(\mathbf{x}_t) = & \max_{\{c_t, h_t, b_t^{ss}, b_t^{dc}\}} \left\{ U(c_t, l_t) \right. \\
 & + \beta \pi_{t+1}^s \left[ \pi_{bad|m_t}^m \int \left( \int V^{dc}(\mathbf{x}_{t+1}) f(w_{t+1}|w_t) dw \right) g(q_{t+1}^{dc}) dq^{dc} \right. \\
 & + \left. \left. (1 - \pi_{bad|m_t}^m) \int \left( \int V^{dc}(\mathbf{x}_{t+1}) f(w_{t+1}|w_t) dw \right) g(q_{t+1}^{dc}) dq^{dc} \right] \right. \\
 & \left. + \beta(1 - \pi_{t+1}^s) b(a_{t+1}) \right\} \quad s.t.
 \end{aligned}$$

$$a_{t+1} = a_t + y((1 - cr_w)w_t h_t, y_{st}, \bar{r}a_t, \tau) + b_t^{ss} \times ssb_t + tr_t - c_t,$$

(1), (6), (8), and (9).

The decision problem in the *complete retirement* phase is given by:

$$\begin{aligned}
 V^{dc}(a_t, e_t, m_t) = & \max_{c_t} \left\{ U(c_t, l_t) + \beta \pi_{t+1}^s \left[ \pi_{bad|m_t}^m V^{dc}(a_{t+1}, e_{t+1}, m_{t+1}) \right. \right. \\
 & \left. \left. + (1 - \pi_{bad|m_t}^m) V^{dc}(a_{t+1}, e_{t+1}, m_{t+1}) \right] \right. \\
 & \left. + \beta(1 - \pi_{t+1}^s) b(a_{t+1}) \right\} \quad s.t.
 \end{aligned}$$

$$a_{t+1} = a_t + y(y_{st}, \bar{r}a_t, \tau) + ssb_t + tr_t - c_t,$$

(1), (8), and (9).

## 4 Data and Calibration

The model is estimated using data from the Health and Retirement Study (HRS) in two steps. First, all ten waves of the HRS data from 1992-2010 are used to estimate processes which can be identified without using the dynamic programming model. Lets call this vector  $\Phi$  and includes health transitions, survival probabilities, wages, DB pension benefits and eligibility. In the second step, a sub-sample of the data is used to estimate the preference parameter vector  $\Theta = (\beta, \rho, \nu, \theta_{beq}, \phi_H, \phi_P, \chi)$  using Method of Simulated Moments (MSM). The following sections describe both the data and the calibration exercise in detail.

### 4.1 Data

The HRS is a longitudinal sample of non-institutionalized individuals in the U.S., over the age of 50. The first primary cohort (born in 1931-1941) was interviewed in 1992 and subsequently every two years. Four more cohorts were added later to address sample attrition due to deaths — Children of Depression (CODA) (born 1924-1930), War Babies (born 1942-1947), Early Baby Boomers (born 1948-1953) and Mid Baby Boomers (born 1954-1959). Along with the age-eligible respondents, the survey also interviewed the spouses or partners of the respondents. The HRS has a rich source of information on demographics, health, financial wealth, private pensions, Social Security, government transfers, income, labor market activity and retirement. For those respondents who gave permission to access their administrative records, the HRS data can be matched to the Social Security earnings data from SSA and pension plan information from the employers. These provide very accurate measure of Social Security and pension wealth accrued from both DB and DC plans. These restricted earnings and pension data from the Social Security Administration and employers respectively are used to construct a measure of Social Security and pension wealth held by the individuals in the model at age 55.

Data on male household heads with either a DB, DC plan or those without any pension is used. Since the theoretical model in this paper does not allow for combination pension plans,



individuals on hybrid plans are dropped from the sample. I also drop observations on account of missing values for hours, wages and assets. Since self-employed workers face different financial incentives for reducing hours (not captured in the model), I drop them from the sample. Further, this is merged with the restricted pension wealth and Social Security data to provide a measure of pension and Social Security wealth at the beginning of the model simulations.

## 4.2 Social Security

Social Security wealth at age 55 is computed using the Social Security rules and Summary Earnings data provided by the HRS. Details about the construction of AIME is provided in appendix A.

Since a majority of the HRS respondents first became eligible for Social Security in the year 1998, I use the 1998 formula from the SSA for computing these benefits. Table 2 gives the parameters of the benefit function defined in equations 3 and 4 as well as the earnings test threshold and taxes. Furthermore, benefits are reduced by 6.7% for every year before the NRA that these benefits are

Table 2: Social Security Benefit Formula

Parameter	Value*	
	Under age 65	65-69
$b_0$	3,720	3,720
$b_1$	22,392	22,392
$e^{max}$	68,400	68,400
<i>Earnings Test</i>		
Threshold	9,120	14,500
Tax	0.50	0.33

\*1998 rules from SSA

claimed. For instance, if the benefits are claimed at age 62, they are permanently reduced by 20%.

Social Security benefits are also increased by 6.5% for every year past NRA that the claim is delayed. These rules are pertaining to the average birth cohort in my estimation sample (those born between 1937-1938).

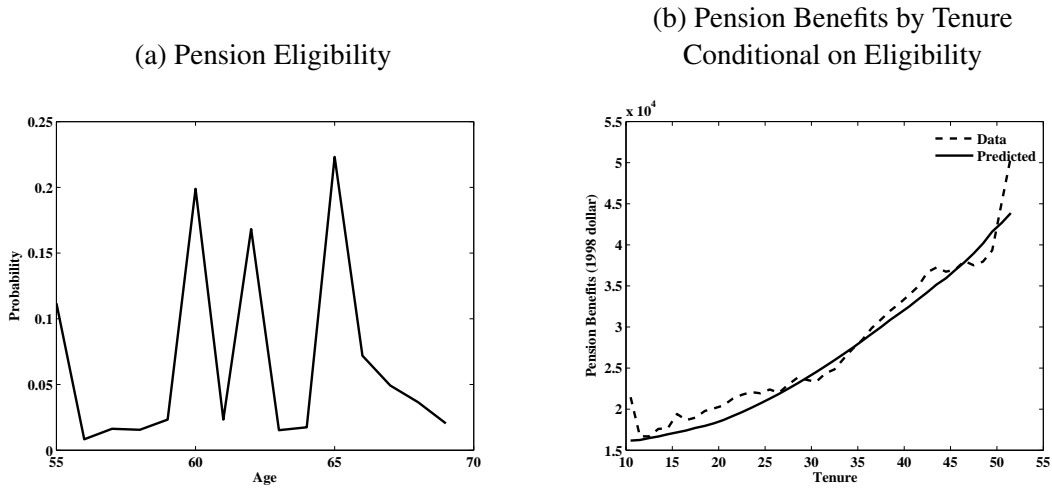
### 4.3 Pension

In order to identify the pension types — *db*, *dc* and *no*, employer provided data on pension is used. The unrestricted HRS data provides self-reported information on the type of pension plan held on the current job. However, there are reports of multiple plans and it is difficult to identify the main pension plan based on self reports alone. Refer to appendix B for details on constructing plan indicator for *db* and *dc* type. The *no* type individuals are those who either have zero pension wealth based on the restricted pension data or those who self-report having no pension plan on the job. The Pension Estimation Software provided with the restricted pension data is used to calculate pension wealth under the main plan at age 55 for each of the HRS respondents which is then used as part of the initial conditions for the structural model.

Pension eligibility for DB plans are directly taken from the restricted pension data. The Pension Estimation Software gives a measure of pension wealth at each age between 50 and 70. Age of pension eligibility is constructed as the age at which the pension wealth becomes positive for the first time. Age and tenure specific probabilities are then constructed by simply averaging over these. Figure 4a plots age-specific probabilities (conditional on not being eligible earlier) of pension eligibility. The most common ages of pension eligibility are 55, 60, 62 and 65. Conditional on being eligible for pension, benefits are approximated as a function of AIME and tenure with the pension provider. Pension benefits increase with tenure as shown in figure 4b. The figure shows mean predicted and actual pension benefits for the HRS respondents by tenure conditional on being eligible. Estimates from the OLS regression are provided in appendix table C.1.

I use estimates from Poterba et al. (2007) for the employer and employee contribution rates for the DC pension plan. The authors estimate a joint contribution rate of 8.3 percent of earnings for HRS males with positive DC contributions which comprises of a mean employee rate  $cr_w$  of 6.6%

Figure 4: DB Pension Eligibility and Benefits



and a mean employer rate  $cr_e$  of 1.7%. The mean rate of return on DC balances  $\bar{r}$  is set to 7% to match the long-term average annual rate of return (1967-2016) on three different investments — S&P 500 Index, 3-month Treasury Bill and 10-year Treasury Bond<sup>16</sup> and the standard deviation  $\sigma_\psi$  of the shock is set to 1.4%<sup>17</sup>. Finally the risk free rate of return  $r$  on non-pension assets is set to 4%.

#### 4.4 Health and Survival

Health transitions are estimated by running an ordered probit of self-reported health status<sup>18</sup> on previous year health status<sup>19</sup>, education, cohort, and a quadratic function of age. Figure 5a shows the age-specific health transition probabilities for the HRS cohort used in this analysis. The probability of being in bad health increases with age. However, individuals in bad health at age 60 have almost a 6 times higher chance of being in bad health in the next period than individuals in good health.

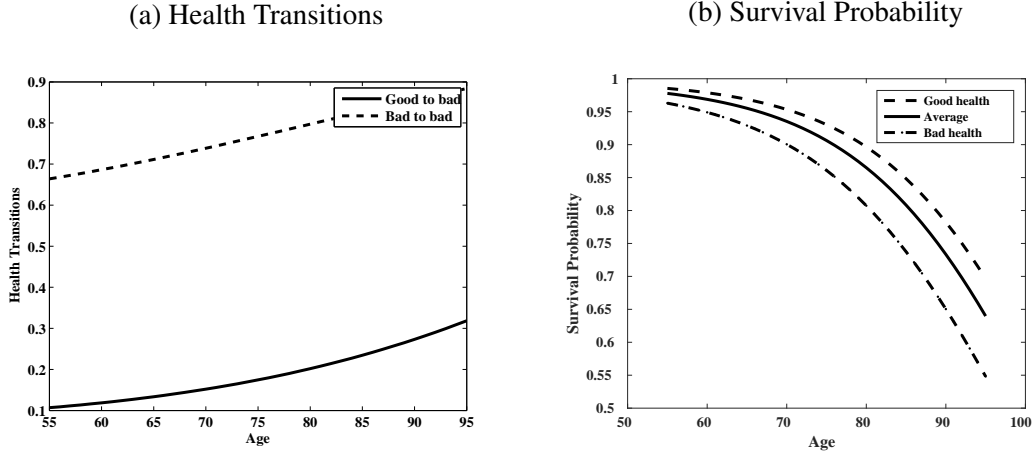
<sup>16</sup>The data comes from the Federal Reserve database in St. Louis.

<sup>17</sup>While this is somewhat arbitrarily set, I try different values between 2% to 10% and it does not seem to have an important effect on the main results of the paper.

<sup>18</sup>The Health and Retirement Survey asks respondents to self report their health on a scale of 1 to 5 where 1 is "Excellent", 2 is "Very Good", 3 is "Good", 4 is "Fair" and 5 is "Poor". For computational simplicity, the 5-point scale is converted into a 2 point scale by grouping individuals of "fair" and "poor" health into the bad health category.

<sup>19</sup>In-between wave information is imputed using previous/next period waves. The probabilities are robust to a variety of imputation methods.

Figure 5: Health and Mortality Transitions



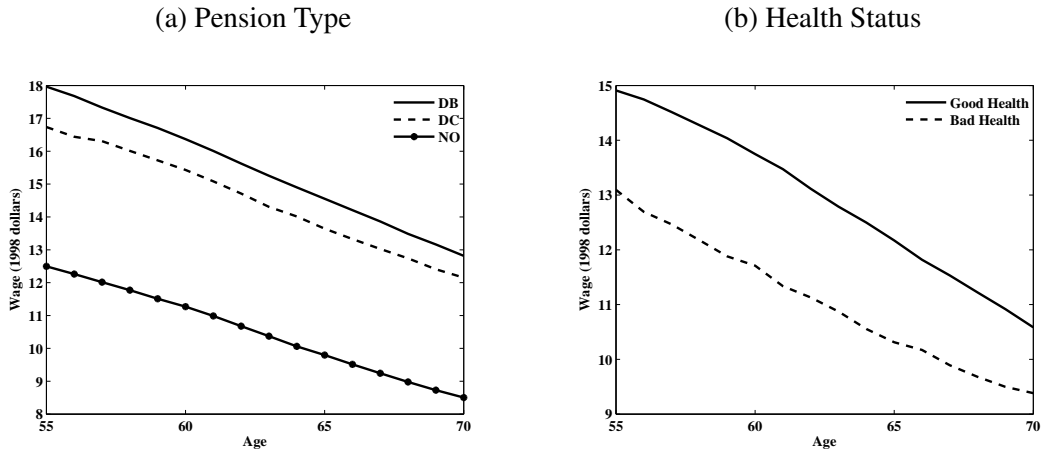
The HRS Tracker file has information on death dates of the respondents which are used to construct age and health specific survival probabilities by running an ordered probit model of death indicator on self-reported health status, age quadratic, education and cohort dummies as mentioned earlier. Figure 5b shows age and health specific survival probabilities used in the structural model.

## 4.5 Wages

The age and health-specific labor productivity profile for each pension type  $\omega^{pen}(m_t, t)$ , is estimated using the Heckman selection model (Heckman, 1976; Gronau, 1974; Lewis, 1974) to adjust for selection bias in observed wages.

The selection equation (labor force participation) is estimated by a probit regression model, and the predicted probabilities are used to generate the inverse Mill's ratio  $\hat{\lambda}_R$ . In the second step,  $\hat{\lambda}_R$  is added to the wage equation which is estimated using OLS regression for those supplying positive hours in the labor market. Please refer to appendix tables C.2 and C.3 for first and second stage regression results. These estimated profiles are used in equation 2 to simulate wages for each pension type which is then fed to the dynamic programming model. The autoregressive coefficient ( $\rho_w$ ) and variance of wage shocks ( $\sigma_{\epsilon_w}^2$ ) are set to 0.977 and 0.014 respectively following the literature (Borella et al., 2017; French, 2005; Casanova, 2010; Card, 1991). Figure 6 shows simulated

Figure 6: Wages by Pension Type, Health Status and Age



wages from equation 2 by pension type and health status. While life cycle wages remain similar for the Defined Benefit and Defined Contribution types, they are considerably lower for those who are without any pension plan. Health also lowers labor productivity as shown in figure 6b.

## 4.6 Taxes

Individuals pay federal and payroll taxes. Payroll taxes in the U.S. are used to fund the federal Old-Age, Survivors, and Disability Insurance (OASDI) and Medicare programs. Due to a great deal of variation in state income taxes, I do not allow individuals to pay state taxes in the model. The rates used are those applying to a “Head of Household” in 1998 with the standard deduction (individuals are not allowed to itemize actual deductions such as medical expenses). The OASDI taxes were 6.2% with a maximum taxable base of \$68,400 and the Medicare taxes were 1.45% with no cap in 1998. Table 3 gives the federal income tax schedule used in the model.

## 4.7 Preference Parameters

In order to make sure that the individuals in the model face similar Social Security and pension rules as those in the data, I fit my model to the initial HRS cohort. Initial conditions (state vector at age 55) are generated by taking random draws from the empirical joint distribution of household assets, wages, Social Security wealth, pension wealth, tenure and pension plan type. Table 4

Table 3: Federal Income Tax

Pre-tax Income (Y)	Post-Tax Income	Marginal Tax Rate
0 – 6,250	Y	0.00
6,250 – 40,200	$6,250 + (Y - 6,250) * 0.75$	0.15
40,200 – 93,950	$31,713 + (Y - 40,200) * 0.72$	0.28
93,950 – 148,250	$70,413 + (Y - 93,950) * 0.69$	0.31
148,250 – 284,700	$107,880 + (Y - 148,250) * 0.64$	0.36
284,700+	$195,208 + (Y - 284,700) * 0.61$	0.39

summarizes the initial distribution. It shows that individuals with a Defined Benefit plan have both lower pension and non-pension wealth than individuals with Defined Contribution plans. However, they have slightly higher wages and better health than the latter group. Those without any pension plans have the lowest private and Social Security wealth and wages. These individuals also tend to have the worst health.

Table 4: Summary Statistics for the Initial Conditions

	<i>db</i>	<i>dc</i>	<i>no</i>
Age			
Mean	57.3	57.2	57.3
Standard Deviation	1.7	1.7	1.7
Assets (in thousands of 1998 dollars)			
Mean	206.0	223.8	199.4
Standard Deviation	274.5	321.9	389.7
AIME (in thousands of 1998 dollars)			
Mean	27.4	32.2	21.8
Standard Deviation	12.8	12.3	12.4
Pension Wealth (in thousands of 1998 dollars)			
Mean	50.6	87.8	-
Standard Deviation	148.0	105.5	-
Wage (in 1998 dollars)			
Mean	18.0	16.8	12.5
Standard Deviation	8.3	9.3	7.8
Fraction in bad health	0.10	0.13	0.18
Number of obs.	770	289	1,577

## Method of Simulated Moments

Given the vector of exogenous data generating processes  $\Phi$  and some vector of preference parameters  $\Theta$ , I solve for the decision rules  $c(\mathbf{x}_t, \Phi, \Theta)$ ,  $h(\mathbf{x}_t, \Phi, \Theta)$ ,  $b^{ss}(\mathbf{x}_t, \Phi, \Theta)$  and  $b^{pen}(\mathbf{x}_t, \Phi, \Theta)$ . I then use the estimated  $\Phi$  and initial conditions  $\mathbf{x}_0$  to simulate the life cycle profiles of hypothetical individuals. Finally an MSM criterion function is used to find  $\hat{\Theta}$  that minimizes the distance between aggregated simulated and data profiles. The following moments are matched to estimate the elements of  $\Theta$ :

1. Participation by pension plan type, health and age resulting in  $6 \times T$  moment conditions.
2. Log of hours worked conditional on participation by pension plan type, health and age resulting in  $6 \times T$  moment conditions.
3. Mean assets by pension plan type and age resulting in  $3 \times T$  moment condition

This gives a total of  $15 \times T$  moment conditions. Formally the MSM estimate  $\hat{\Theta}_{MSM}$  is one that solves:

$$\hat{\Theta}_{MSM} = \operatorname{argmin} \tilde{g}(\Theta, \Phi) W_T \tilde{g}(\Theta, \Phi)$$

Where

$$\underbrace{\tilde{g}(\Theta, \Phi)}_{15T \times 1} = \left[ \begin{array}{c} \frac{1}{N} \sum_{i=1}^N \{p_{it} - \tilde{p}_t^{j,m}(\mathbf{x}_{it}, \Theta, \Phi)\} \\ \frac{1}{N} \sum_{i=1}^N \{\log h_{it|p_{it}>0} - \log \tilde{h}_{t|p_t>0}^{j,m}(\mathbf{x}_{it}, \Theta, \Phi)\} \\ \frac{1}{N} \sum_{i=1}^N \{a_{it} - \tilde{a}_t^j(\mathbf{x}_{it-1}, \Theta, \Phi)\} \end{array} \right]$$

$t = \{1, \dots, T\} \quad j \in \{db, dc, no\} \quad m \in \{good, bad\}$

$W_T$  could be an optimal weighting matrix given by the inverse of a consistent estimate of the covariance matrix of data moments. However efficient choice of weighting matrix could introduce

finite sample bias (Altonji and Segal, 1996). Hence I use the following non-optimal weighting matrix for the structural estimation in this paper:

$$\underbrace{W_T}_{15T \times 15T} = \left[ \text{diag} \left( \text{var} \left( \frac{1}{\sqrt{N}} \sum_{i=1}^N m_{it} \right) \right) \right]^{-1}$$

Where  $m_{it}$  is a vector of data moments

## 5 Results

This section reports the results related to the structural estimation of the preference parameters using MSM, properties of the benchmark model and counterfactual experiment results.

### 5.1 Preference Parameter Estimates

The structural model is used to estimate the preference parameter vector  $\Theta$  as outlined in the previous section by matching moments on labor supply and non-pension wealth evolution (see French (2005) for a discussion on identification). Table 5 provides the parameter estimates from Method of Simulated Moments. Total annual time endowment  $\bar{l}$  is fixed at 5755 hours. Notice that the estimates suggest that participation in the labor market is expensive and costs roughly 30% of the total time endowment. This is consistent with a broad range of estimates in the literature (Borella et al., 2017; French and Jones, 2011; French, 2005; Cogan, 1980). On the other hand, a period of bad health costs 6% of time in addition to productivity losses captured through the effect of bad health on labor earnings. Individuals on Defined Benefit plans who choose to continue working after claiming their pensions experience a loss of 2.6% in their time endowment. Since these individuals can only claim benefits after retiring from their pension jobs, this parameter very broadly captures the nature of “bridge job” which are often part-time and/or may involve occupational downgrading (Quinn, 1999; Ruhm, 1990).



Table 5: Estimated Preference Parameters

Parameter	Definition	Value
$\beta$	discount factor	0.998
$\rho$	coefficient of relative risk aversion	3.32
$\nu$	consumption weight	0.58
$\theta_{beq}$	bequest weight	1.71
$\phi_H$	hours of leisure lost due to bad health*	350
$\phi_P$	participation cost*	1805
$\chi$	hours lost due to pension employer switch*	150

\*Assuming a total annual time endowment  $\bar{l}$  of 5755 hours

## 5.2 Benchmark Model

One of the key goals of the paper is to explain systematic differences in retirement behavior across the pension types *db*, *dc* and *no* based on observable differences in accrual of pension wealth close to the years before retirement. As a result of which, the model though complex, has a set of preference parameters which are common to all types (with the exception of  $\chi$ ). The differences in work disincentives thus operate solely through the budget constraint and the processes governing the evolution of pension wealth.

Figure 7 shows that the model does fairly well in capturing the heterogeneity in retirement behavior across the three pension types, especially with respect to the labor force participation rates. The three types of individuals — *db*, *dc* and *no* experience different retirement incentives in the model. For instance, individuals with no pension plans (*no* type), reduce labor supply due primarily to Social Security work disincentives (as explained in section 3.4), declining health and labor productivity. On the other hand, *db* type individuals in addition to these also face incentives provided by their pension plan. Upon reaching the pension eligibility age, they have a strong incentive to quit working. Social Security benefits along with pensions replace 94% of the pre-retirement income for an average *db* type individual in the model. Social Security earnings test,

declining labor productivity and health provides further incentives for retirement.

Finally, individuals with Defined Contribution plans (*dc* type) face different pension rules than *db* type. Participation rates are fairly high until age 60 as the pension account cannot be claimed until then. Unlike Defined Benefit plans, pension wealth potential of the DC plan grows as long as the individual works with the pension provider. Continuation of work after age 60 results in gains in pension wealth through the employer contribution. Individuals can also claim their pension account while still working for the pension provider.

Figures (7b), (7d), and (7f) show the hours worked (conditional on participation) between ages 55 and 70 in the model and data for the three pension types. While the model is able to fit the overall decline in hours at older ages, it systematically under-predicts hours worked at relatively younger ages and over-predicts hours worked at older ages for the *db* and *dc* type. A potential solution to this issue is allowing for age-varying participation cost as in the case of French and Jones (2011). However, an age-invariant fixed cost is chosen to keep the framework as simple as possible while still allowing for the richness in pension structure.

Figure C.1 in the appendix provides the participation rates and hours (conditional on participation) by health status for each pension type. The model performs well in fitting the participation rates and hours worked for each pension type in the good health state (with the exception of hours worked for *no* type). However, it is not able to capture the decline in participation rates due to bad health. The model systematically over-predicts participation rates and under-predicts hours worked in bad health state across all three pension groups (with the exception of hours worked for *no* type). This is not surprising given the simple model of health used in this analysis. For *db* and *dc* type individuals in the model, any period of non-participation before claiming pensions can imply a significant loss in pension wealth as the model does not distinguish between non-participation and retirement. Individuals can not go back to working with their pension provider after a period of non-participation. This means that they will not be able to reach the full pension wealth potential of their plans. As a result, in the event of a bad health shock, individuals in the model respond by reducing hours and not participation.

Figure C.2 in the appendix provides non-pension wealth profiles for each pension type both in the data and the model. The model does a good job in matching these age-specific wealth profiles for *db*, *dc* and *no* type individuals. However, it slightly over-predicts assets before age 60 for the *db* and *no* type individuals. Finally appendix figure C.3 shows the pension benefits under a DB plan at the age of pension eligibility. Even though the model uses a relatively simple approximation of the DB pensions, it is able to capture the correlation between the NRA of the pension plan and generosity of pension benefits.

The following sections use the benchmark model to conduct several counterfactual experiments related to pension plan shift and Social Security policy changes.

### **5.3 Counterfactual Experiments**

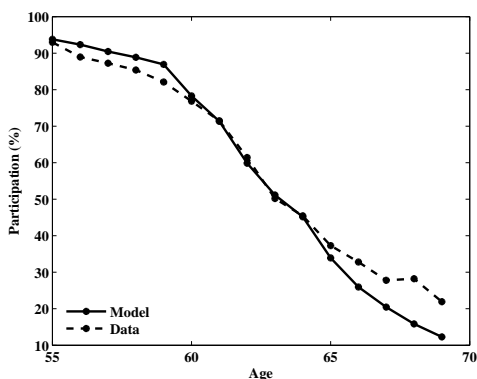
The estimated model is used to simulate the effect of pension plan shift from Defined Benefit to Defined Contribution on labor force participation of older men. I simulate the effect of a 50% drop in DB pension plans in two different ways. First, I randomly change the pension plans for some individuals in the sample without changing any of the other initial conditions. Second, I allow for the changes in the initial wage, health, Social Security wealth, pension wealth and so on along with the change in pension plan composition. Finally, I compare the magnitude of the effect of these changes on average labor force participation rates to two important Social Security policy changes that have taken place in the recent times: 1) an increase in the Social Security NRA from 65 to 66 and 2) removal of retirement earnings test for those above the NRA.

#### **Pension Composition Change (I)**

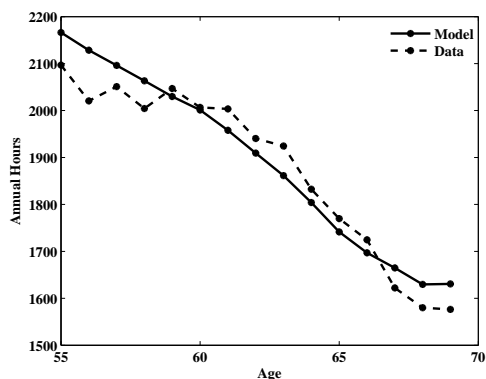
In the first experiment, I randomly switch 50% of the DB pension plan holders in the model to a DC pension plan at the start of the simulations at age 55 while keeping all the other initial conditions the same. For instance, these individuals still have the same pension wealth, wages, non-pension wealth and Social Security wealth at age 55 as earlier. But the rules for future pension wealth accumulation changes to that of the *dc* type for them. Figure 8 shows the results of this

Figure 7: Model vs. Data Profiles  
Participation and Hours

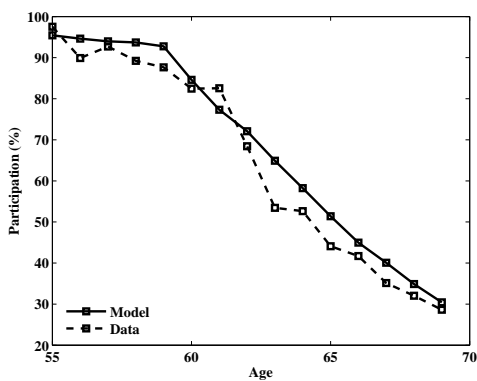
(a) Participation (*db* type)



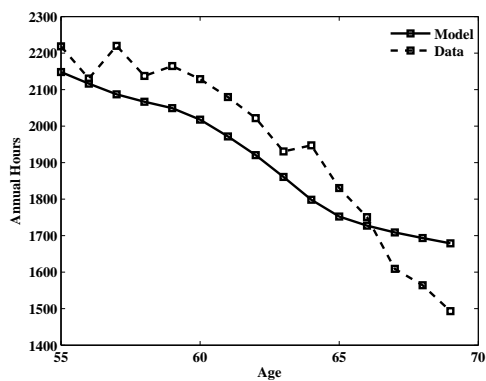
(b) Hours (*db* type)



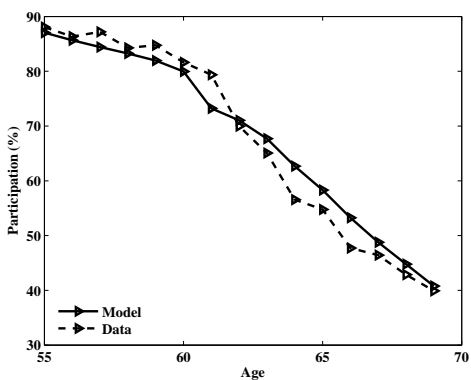
(c) Participation (*dc* type)



(d) Hours (*dc* type)



(e) Participation (*no* type)



(f) Hours (*no* type)

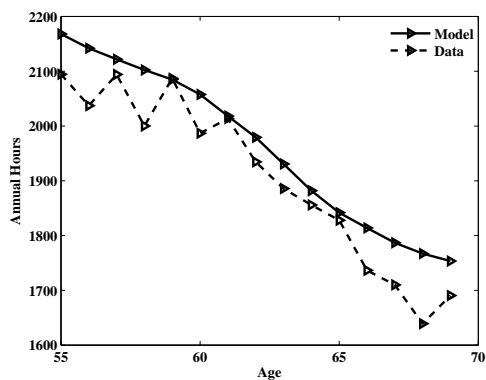
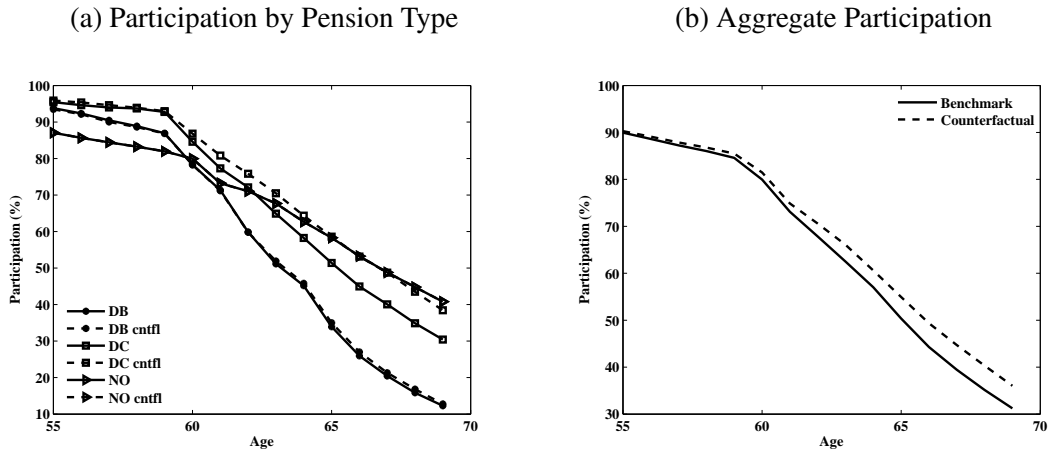


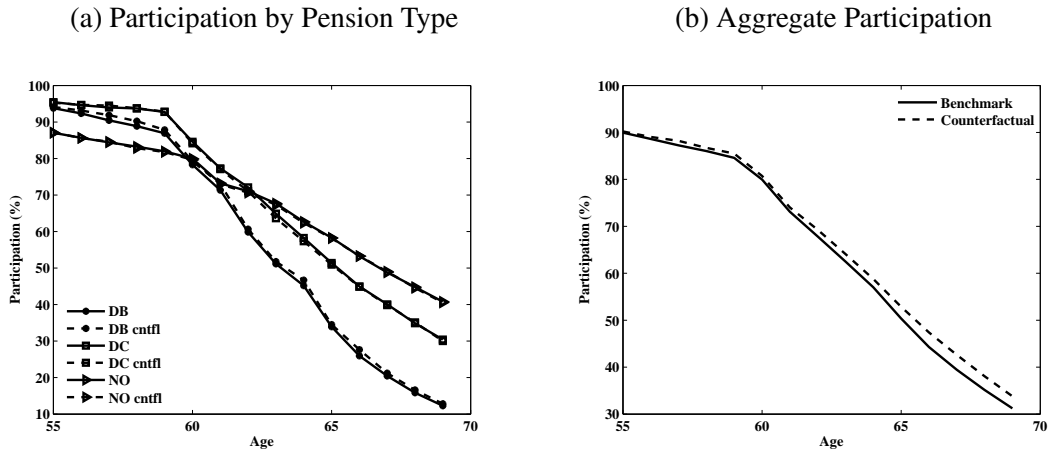
Figure 8: Pension Composition Change (I)



experiment on labor force participation rates. The first panel shows the participation rates by pension plan type for both the benchmark and the experiment. Notice that this experiment does not result in any change in participation rates for the *db* and *no* type individuals. However, the participation rates increase for the *dc* type which now comprises of both the “benchmark” *dc* and “counterfactual” *dc* type individuals. While the former group still observes the same initial conditions as in the benchmark case, the latter group sees a 42% lower pension wealth in their DC account and a roughly 7% higher wage (refer to table 4) at age 55. Lower initial pension wealth and increased future pension wealth potential (through higher wages) result in delayed pension claims by the *dc* type as shown in appendix figure C.4a. For instance, pension claims at age 60 under this experiment are 24% lower than the benchmark case. Individuals delay pension claims by working longer with the pension provider. As a result, the participation rates are 6% to 16% higher between ages 61 and 65 by the *dc* type under this experiment.

The overall increase in labor force participation as shown in the right panel of figure 8 is thus coming from both a change in pension composition as well as higher participation rates by the *dc* type individuals. There is an overall increase in participation by 3% to 10% between ages 61 and 65 as shown in table 6. The last row of the table shows the total number of years spent in the labor market on an average between ages 55 and 69. This experiment results in a 4% increase in the total number of work years at older ages, coming mostly from the labor supply response of the *dc* type.

Figure 9: Pension Composition Change (II)



### Pension Composition Change (II)

The nature of the pension plan shift in the earlier experiment resulted in an overall increase in labor force participation rates due to both higher composition of *dc* type individuals as well as increased participation rates by them.

DB pension plan holders are also different from DC pension plan holders along other dimensions like non-pension wealth, wages etc. Table 4 shows that *dc* type individuals have slightly lower assets and wages at age 55 than the *db* type. In order to allow for these correlations, I randomly switch 50% of the DB pension plan holders to a DC plan and also allow for the same distribution of pension wealth, wages, assets, and Social Security wealth that a *dc* type individual observes at age 55. Figure 9 shows the results of this experiment on labor force participation rates. The first panel shows the participation rates by pension plan type for both the benchmark and the experiment. Notice that now pension specific participation rates are almost identical to the benchmark case for all three pension types. Appendix figure C.4b shows that age-specific pension claiming rates for the *dc* type also remain the same between the benchmark and the experiment.

Table 6 shows that the overall labor force participation increases by 2% to 6% between ages 61 and 65. I find somewhat smaller effect of this experiment on average labor force participation rates as unlike the first experiment, the effect here is purely due to pension compositional changes.

## Social Security Normal Retirement Age

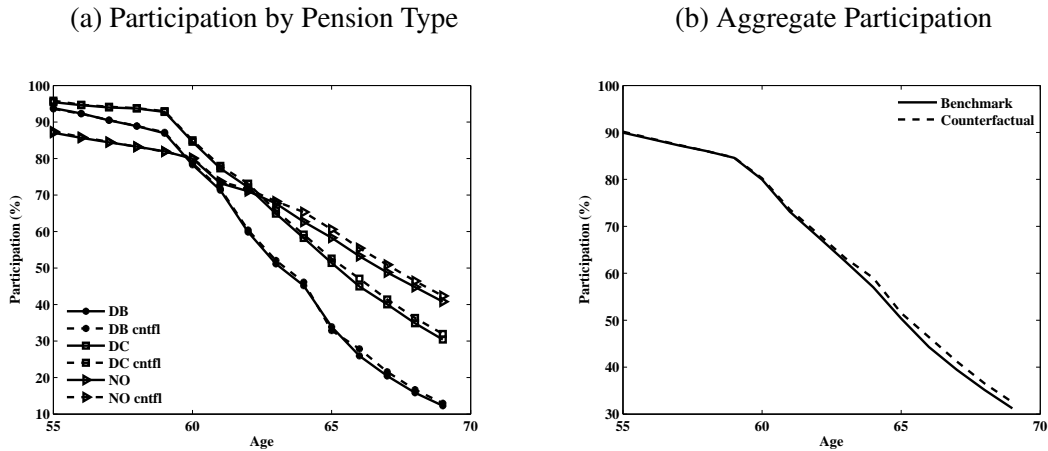
The 1983 Social Security amendments phased in a gradual increase in the NRA resulting in different birth cohorts observing different ages for collecting full Social Security benefits (Svahn and Ross, 1983). While most of the individuals in my sample (HRS cohort) observed an NRA of 65, cohorts born after could face an NRA as high as 67 (birth cohorts 1960 and later). Since most of the baby boomers who have been retiring over the last few years experienced an NRA of 66, in this experiment, I increase the Social Security NRA for all the individuals in my sample from 65 to 66. Raising the NRA results in three important changes. First, it effectively eliminates a year's worth of benefits. Second, it increases the cost of early application. Individuals applying for Social Security at age 62 would now experience a reduction in benefits by 25% due to increased distance from NRA and finally individuals would be subject to a stricter earnings test at age 65.

Figure 10a shows the effect of this experiment on labor force participation rates for each pension group. Notice that the change in participation rates are most salient for those who are without any pension plan (*no* type) and least significant for the *db* type. This is not surprising as Social Security is the most important source of retirement income for individuals without any pension plans. As a result, this group is most sensitive to any changes in Social Security benefits.

Figure 10b and table 6 show the effect of this experiment on average labor force participation rates. Reduced retirement benefits result in an increase in labor supply due to the wealth effect. Average years of work increase by 0.13 years. The overall participation rates increase by 2.41% at age 65 and 4.18% at age 69. Notice that the stricter earnings test results in a smaller increase in participation at age 65 as compared to later years.

The change in participation is mostly coming from individuals delaying their Social Security claims. Overall Social Security application rates drop by 51.7% at age 65 and increase by more than 13 times at age 66 under this experiment (Refer to appendix figure C.5). Application rates also drop by 11.7% at age 62 due to increased cost of early application.

Figure 10: Change in Social Security Normal Retirement Age



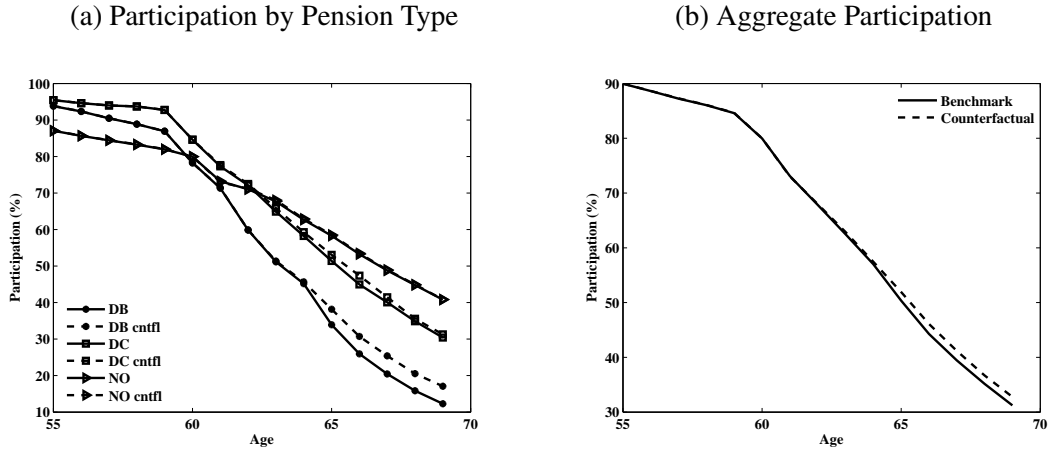
### Social Security Earnings Test

In 2000, the earnings test was removed for older individuals from ages NRA to 69. However, they were still subject to the test till they reached the NRA. In this experiment, I remove the earnings test for individuals 65 and older to be consistent with the reform. Figure 11 shows the effect of this experiment on average labor force participation rates and by pension plan type. Contrary to the earlier experiment, here we see the biggest effect on participation rates for the *db* pension type and the smallest effect for the *no* pension group. Participation at age 65 increases by 13.7% for the former group and only by 0.38% for the latter. However, we do see a big intensive margin response by the *dc* and *no* type individuals. While hours worked at 65 increases by 8.1% for the *db* type, it increases by 11.7% and 6.3% for the *dc* and *no* type individuals respectively. Individuals without any pension plans have the lowest earnings potential in the model. As a result most of them are either naturally below the earnings test threshold amount (\$14,500) or bunch below the threshold by choosing hours. (Friedberg (1999) finds substantial bunching of the elderly workers just below the earnings exempt amount). As a result we do not find any changes in labor participation rates for this group. Pre-tax earnings at age 65 increase by 22% for the *db* type, 16.3% for the *dc* type and 22% for the *no* type. Where the increase is mostly coming from the intensive margin response for the last group.

The overall participation rates increase by 3.11% at age 65 and 4.73% at age 69 (refer to table



Figure 11: Change in Social Security Earnings Test



6). Appendix figure C.6a shows the pension claiming behavior for the *db* type individuals is not affected by the removal of the earnings test. They still quit work with their pension employer at the age of pension eligibility. However, individuals who become eligible for pensions after 65 choose to claim pensions by switching to a different employer rather than quitting work all-together. This is evident by a small decline in the retirement frequencies between ages 65 and 67 and a small increase after (refer to appendix figure C.6b).

## 6 No Pension Heterogeneity

Next, I would like to explore the importance of pension plan heterogeneity in explaining the average labor force participation rates of the elderly. Even though preferences are homogeneous across the three pension groups in the model, *db*, *dc* and *no* type individuals observe systematic differences in initial (age 55) state vector, and age-specific component of wage processes along with pension plan heterogeneity. To this effect, differences in retirement behavior could potentially be driven by differences in wage processes themselves and not by differences in pension wealth evolution. To explore the importance of each channel, I first shut-down any heterogeneity in initial wages and wage process by giving every individual in the sample, same average initial wage and an average age-specific component of wage. More specifically,  $\omega^{pen}(m_t, t)$  in equation 2 is same for

Table 6: Counterfactual Experiment Results

Ages	Benchmark Participa- tion Rates (1)	% Change in Participation			
		Pension I (2)	Pension II (3)	SS NRA (4)	SS ET (5)
60	0.80	1.96	1.19	0.34	0.01
61	0.73	2.65	1.54	0.68	0.10
62	0.68	4.40	2.35	0.90	0.25
63	0.63	5.93	2.95	1.20	0.61
64	0.57	6.54	3.67	3.55	0.77
65	0.50	9.42	5.52	2.41	3.11
66	0.44	11.63	7.31	4.65	4.00
67	0.39	13.51	8.43	4.54	4.36
68	0.35	14.92	8.34	3.93	4.38
69	0.31	15.42	7.85	4.18	4.73
Total work years 55-69	9.78	10.21	10.04	9.91	9.87

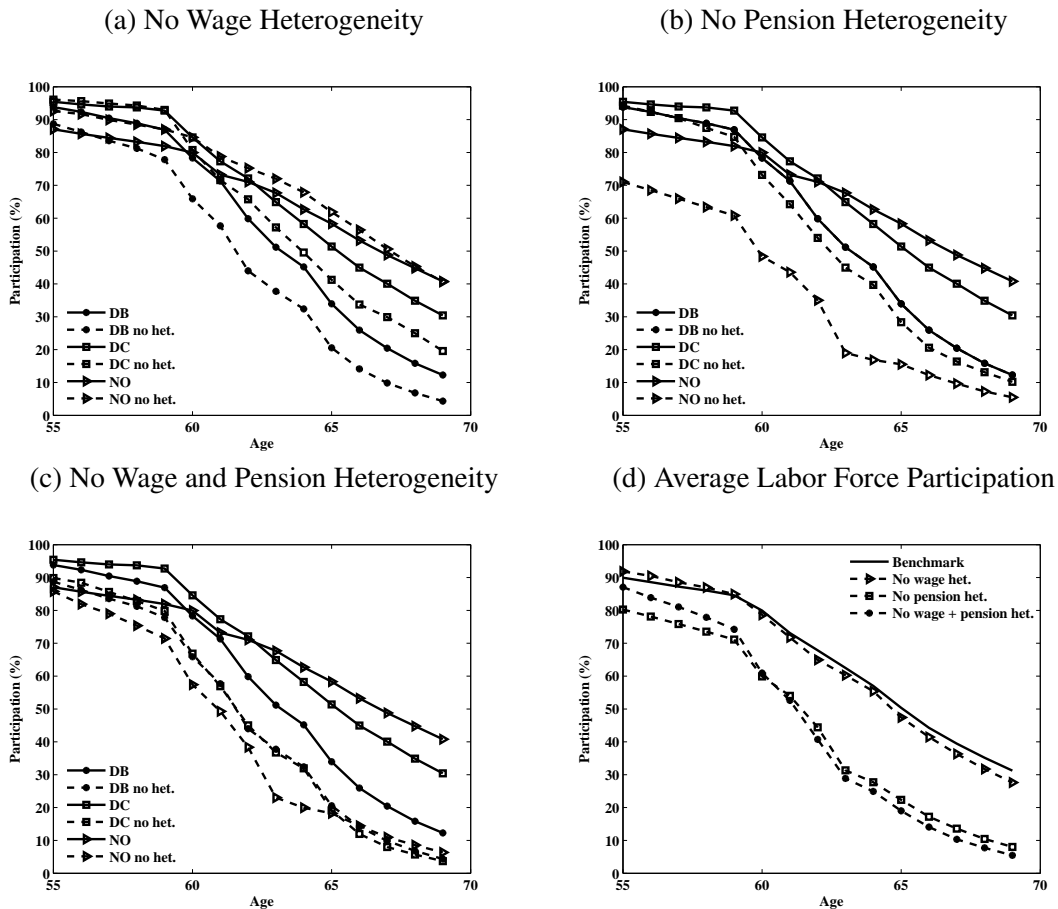
Notes: Columns (2) and (3) have 14% *db*, 26% *dc* and 60% *no* type plan composition. Columns (1), (4)-(5) have 29% *db*, 11% *dc* and 60% *no* type plan

all  $pen \in \{db, dc, no\}$ ). Next, I shut-down pension plan heterogeneity by giving every individual a DB pension plan while keeping everything else the same. Finally, I shut down both pension plan and wage heterogeneity in the model.

Figure 12 shows the effect of these experiments on labor force participation rates. First, we find that shutting down wage heterogeneity results in underpredicting participation rates for *db* and *dc* type individuals and overpredicting for *no* type individuals (see figure 12a). By assigning average wages to all individuals, this experiment effectively lowers life-cycle wages for the two pension groups and raises them for those without any pensions which results in the observed shifts in participation through the substitution effect. But systematic differences in participation rates still hold. However, shutting down pension plan heterogeneity results in highest participation rates observed for the *db* type and lowest for *no* type at all ages between 55 and 70 (see figure 12b). This reversal in retirement pattern is mainly caused by a much lower participation rate observed for the *no* and *dc* type individuals as compared to the benchmark while participation rates remain

identical for the *db* type. Assigning a DB pension plan results in increased retirement benefits for those without pensions as well as sharper labor market exits due to the work disincentives built into these plans for both *dc* and *no* type individuals. Hence, in this experiment we observe that eliminating pension plan heterogeneity eliminates the systematic differences in participation rates across these pension groups as observed in the data. Finally eliminating both wage and pension plan heterogeneity results in closing the gap in participation rates further (see figure 12d). Figure 12d shows that shutting down pension differences has the biggest effect on average labor force participation rates and only a small effect due to eliminating wage differences.

Figure 12: No Pension and Wage Heterogeneity



## 7 Conclusion

In this paper, a stochastic dynamic programming model of retirement, savings, Social Security and pension wealth is estimated. The model allows for a very rich and precise formulation of the budget constraint with respect to the retirement wealth. More specifically, it allows for pension wealth accrual through both Defined Benefit and Defined Contribution pension plans. DB plans in the model provide age specific incentive to retire as seen in practice, whereas DC plans provide a fixed age-independent profile of wealth accrual with uncertainty pertaining to the rate of return on pension wealth.

The analysis conducted in this paper provides several interesting insights. First and foremost, differences in the nature of pension wealth evolution go a long way in explaining the differences in retirement behavior across pension groups. The model performs well in fitting pension specific labor force participation rates at older ages. Heterogeneity in the age of pension eligibility appears to be crucial in determining the timing of labor market exits for individuals on DB plans. On the other hand, declining labor productivity and Social Security rules largely govern participation rates for individuals without any pensions. The counterfactual experiments indicate that change in pension plan composition in the U.S. perhaps had an important role to play in increasing the labor force participation of the elderly with modest contributions from the increase in Social Security NRA. Furthermore, removal of the earnings test had a relatively smaller effect on the extensive margin and bigger effect on hours worked especially for individuals in Defined Contribution plans and those without any pensions.

This analysis is not without limitations. Most notably, it uses a simple model of health and its effect on labor supply. Since most of the health differences and medical expenditure shocks are concentrated at older ages (Deaton and Paxson, 1998; Nardi et al., 2010), any variation in health insurance availability or health stock itself is important in determining retirement behavior. Moreover, at least a part of the increasing labor force participation trend at older ages could be due to recent improvements in health and mortality. The model allows for mortality differences and correlations in health and pension plan type at the beginning of the simulations but abstracts away

from any heterogeneity in medical expenditures or health insurance availability across pension groups. The analysis is also restricted to male household heads and does not account for any heterogeneity across gender or marital status. Recent work by Borella et al. (2017) shows that models estimated without incorporating differences in gender or marital status could miss economy wide aggregate outcomes including labor supply and hours worked. As such, the results of this paper apply to the sample analyzed and any conclusions about the aggregate retirement behavior should be drawn with caution. Finally, the model does not account for selection into pension plan types and may overstate the effect of pension plans on retirement behavior, if individuals select into plans based on their preference for work. Addressing some of these limitations leaves room for future work in these directions.

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## **Appendix**

### **A Social Security Wealth**

The HRS restricted Summary Earnings file provides 1951-2007 annual earnings data for the HRS respondents who gave permission. In computing Social Security benefits, the SSA uses the national average wage indexing series to index annual earnings of a person to ensure that the future benefits reflect the general rise in the standard of living that occurred during his or her working lifetime. The earnings are indexed to the average wage level two years prior to the year of first eligibility (age 62). Since the average age of HRS respondents at the time of first interview was 55, I use the 1997 weights from SSA and 35 highest earning years to compute a measure of indexed earnings. This is then converted into an annualized measure of Average Indexed Monthly Earnings (AIME) by dividing by the number of earning years taken into consideration. The AIME is used in computing the Primary Insurance Amount (PIA) which is basically the Social Security benefits of an individual before any reductions due to earnings test or early application.

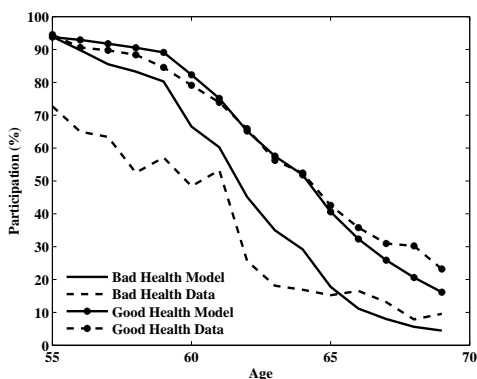
### **B Pension**

For each individual, pension wealth is computed using restricted pension data and the Pension Estimation Software provided by HRS. Restricted pension plan information is available for 2,929 of the HRS respondents and 1,397 unique pension plans in the year 1992. 51% of these individuals report having only one pension plan, 45% report 2 plans and less than 5% report having more than 2 plans giving a total of 3,785 individual-plan observations. For each respondent, pension wealth is computed using the Pension Estimation Program provided by HRS for all possible quit dates between 50 to 70. Then a plan type indicator is assigned to each respondent-plan observation based on having positive pension wealth for each pension plan type at some age between 50 to 70. This classification yields 2,262 DB plans, 1,071 DC plans, 9 combination plans and 443 plans with zero pension wealth. Since combination plans are more generous than both DB and DC plans and provide different work incentives, individuals with these plans are dropped from the sample. For individuals with multiple plans, the main plan is chosen based on the plan with the highest pension wealth potential (maximum wealth that can accrued between ages 50 to 70). This results in 2,051 individuals with DB pension plans and 738 individuals with DC plans. The restricted data is then merged with the unrestricted HRS data.

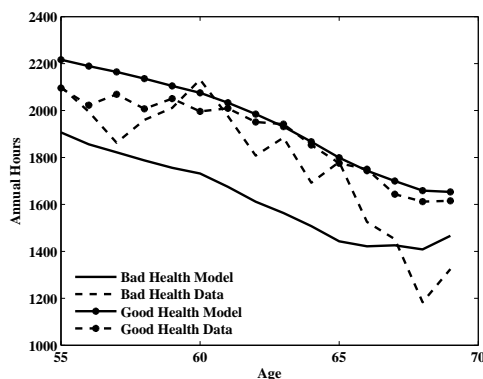
### **C Additional Figures and Tables**

Figure C.1: Model vs. Data Profiles  
Participation and Hours by Health Status

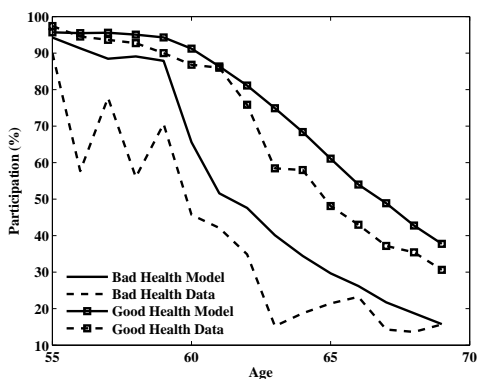
(a) Participation (*db* type)



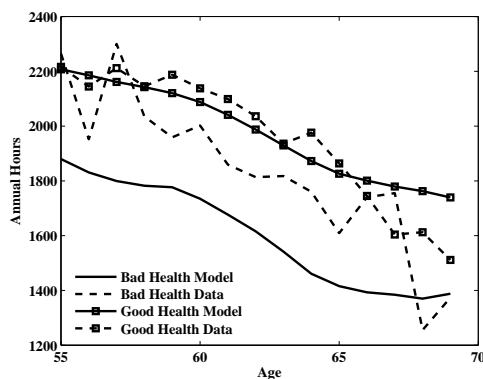
(b) Hours (*db* type)



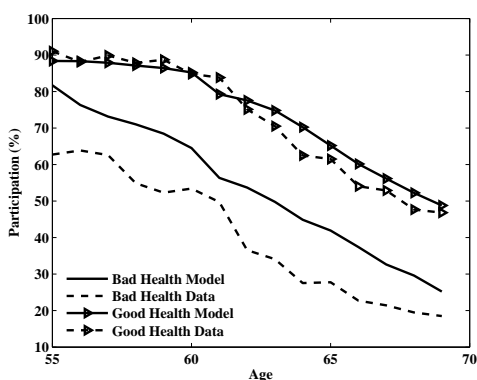
(c) Participation (*dc* type)



(d) Hours (*dc* type)



(e) Participation (*no* type)



(f) Hours (*no* type)

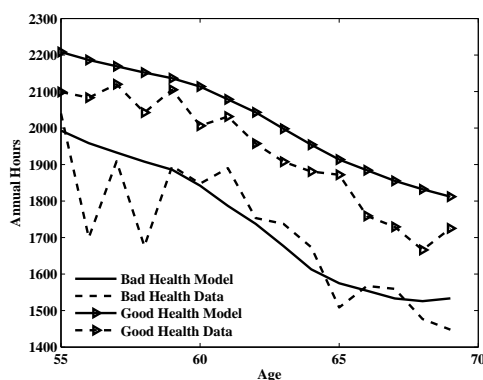


Table C.1: Parameter Estimates from OLS Regression:  
Pension Benefits

Parameter	Estimate
tenure	119.09 (181.32)
tenure $\times$ tenure	15.58*** (2.64)
AIME $\times$ tenure	-0.01*** (0.00)
AIME	0.42*** (0.07)
Observations	6614

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Figure C.2: Model vs. Data Profiles  
Non-Pension Wealth

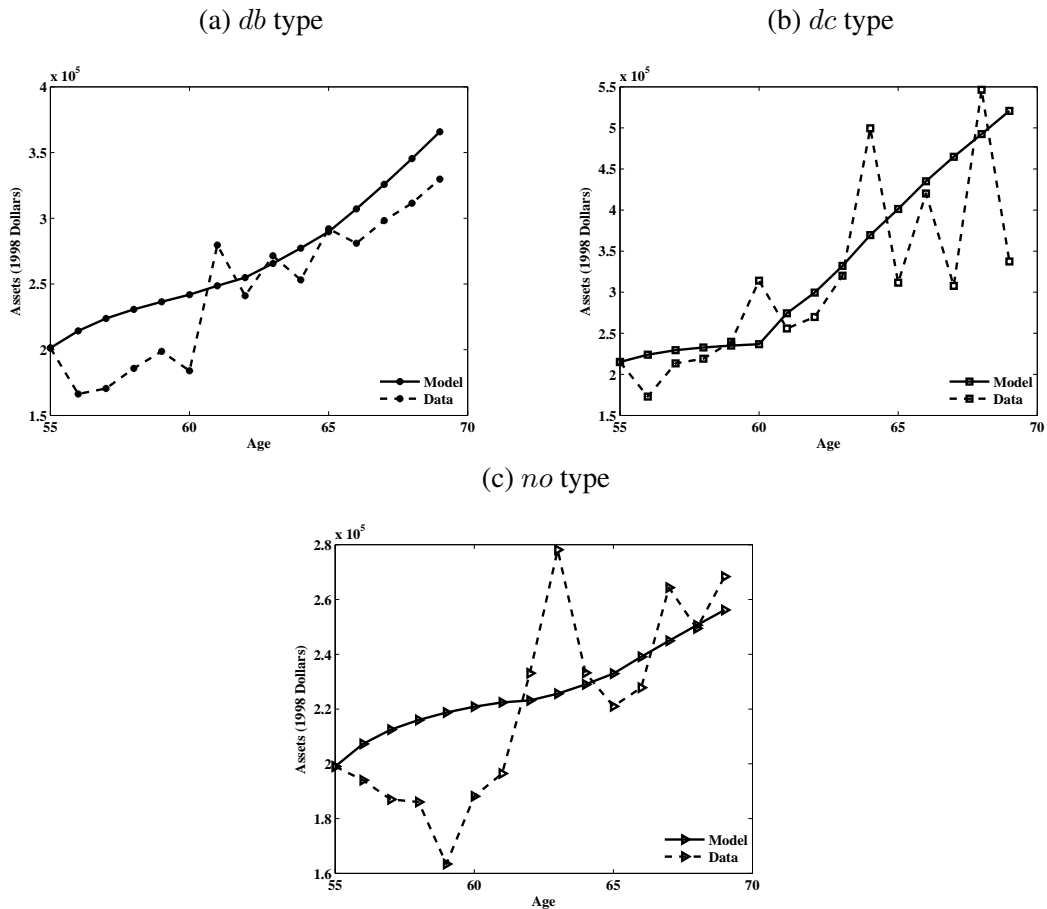


Table C.2: Wage Selection Model  
First Stage Probit Estimates

	Estimates
Age	-0.02*** (0.00)
Bad health	0.05 (0.13)
Age × Bad health	-0.00 (0.00)
<i>Education</i>	
GED	0.06 (0.03)
High-school graduate	-0.05** (0.02)
Some college	-0.09*** (0.02)
College and above	-0.18*** (0.02)
<i>Race</i>	
Black	-0.11*** (0.02)
Other	0.07* (0.03)
<i>Marital Status</i>	
Married, spouse absent	0.00 (0.09)
Partnered	0.10** (0.03)
Separated	0.16** (0.05)
Divorced	0.08*** (0.02)
Separated/divorced	0.21** (0.07)
Widowed	0.12*** (0.02)
Never married	-0.02 (0.03)
<i>Pension Status</i>	
DB	0.44*** (0.02)
DC	0.52*** (0.02)
Observations	65,631

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table C.3: Wage Selection Model  
Second Stage Estimates

	Estimates
Age	0.93* (0.42)
Age <sup>2</sup>	-0.02* (0.01)
Bad health	-5.95 (19.22)
Age × Bad health	0.39 (1.18)
Age <sup>2</sup> × Bad health	-0.01 (0.03)
<i>Education</i>	
GED	0.10*** (0.01)
High-school graduate	0.13*** (0.01)
Some college	0.30*** (0.01)
College and above	0.66*** (0.01)
<i>Pension Status</i>	
DB	0.47*** (0.02)
DC	0.46*** (0.02)
Inverse Mill's Ratio	0.80*** (0.11)
Observations	54,541

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Figure C.3: Model vs. Data Profiles  
DB Pension Benefits at the Age of Eligibility

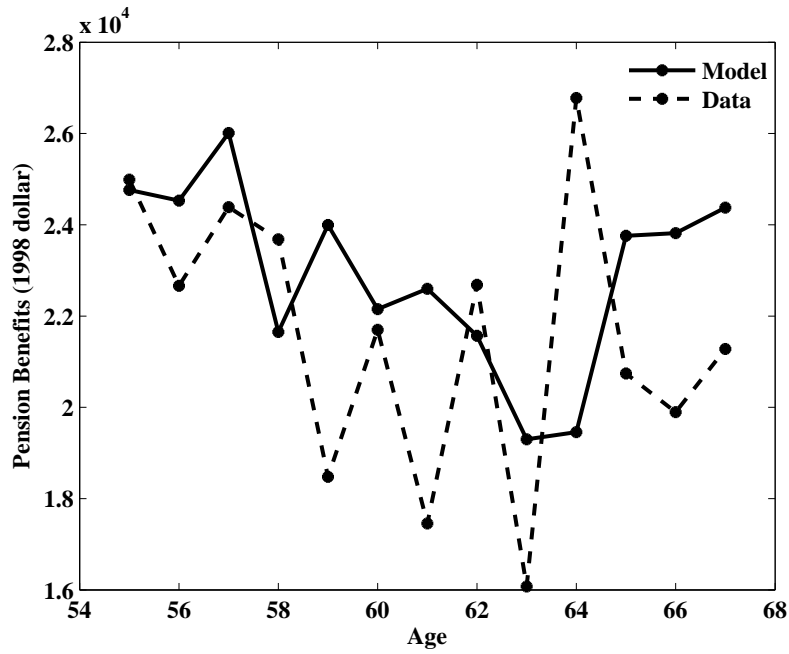
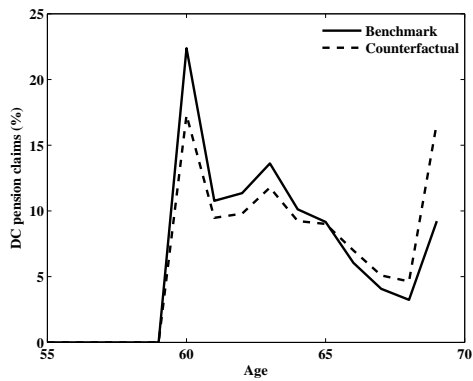


Figure C.4: DC Pension Claim Frequency

(a) Pension Composition Change (I)



(b) Pension Composition Change (II)

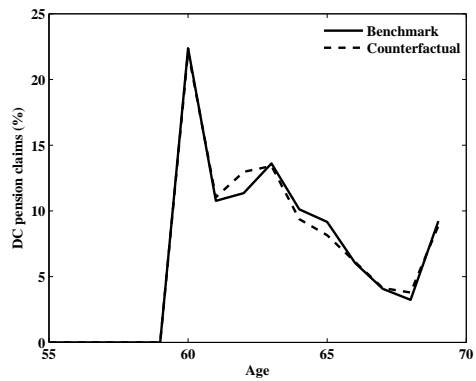


Figure C.5: Average Social Security Application Rates  
Change in Normal Retirement Age

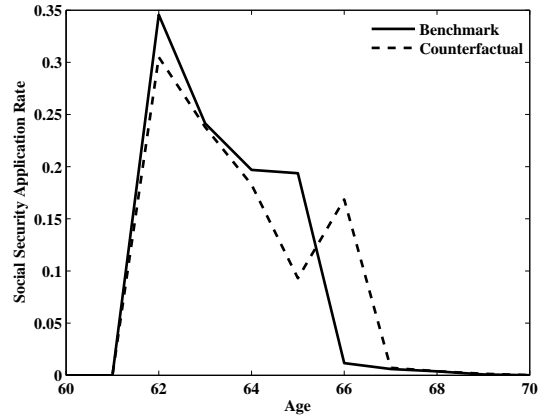
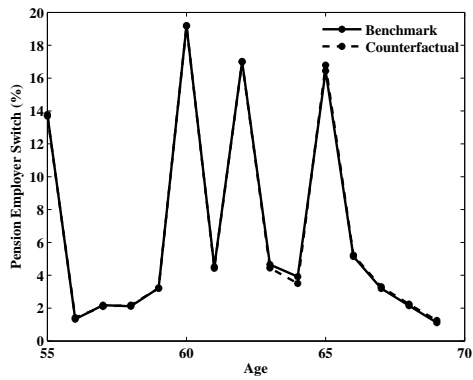


Figure C.6: Retirement Behavior for *db* Pension Type  
Social Security Earnings Test

(a) Pension Employer Switch



(b) Retirement Frequency

