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A Life-Cycle Analysis of Retirement Savings and Portfolio Choices: Optimal Asset Allocation and Location with Taxable and Tax-Deferred Investment

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Abstract of the Dissertation

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The expansion of Defined Contribution (DC) pensions provides households with an opportunity to save and make investments in a tax-favored fashion. Participants in the DC plans can enjoy the tax benefit from their contributions and investment earnings, but also get affected by the pension designs, such as employer matching policies, investment options and illiquid constraint. In this study, I analyze theoretically and empirically the optimal saving and investment decisions of the households in those pension accounts, and show that the pension characteristics play important roles in explaining the households' behavior. There are three essays in the dissertation.

The first essay attempts to explain the observed asset allocation and location decisions for households making taxable and tax-deferred investment. I incorporate employer matching policies and other pension account characteristics into a life-cycle model of optimal intertemporal consumption and portfolio choice, which includes a taxable saving account and a tax-deferred retirement saving account. The model is estimated using data from the Surveys of Consumer Finances (1992 to 2007), and the structural parameters are recovered by the Method of Simulated Moments. After mod-

eling the features of U.S. pension system, the predicted policy rules are able to explain the observed portfolio patterns of American households, who are more likely to hold equities in the tax-deferred pension account. The estimates and results show that employer matching policy induces higher proportion of total wealth held in the pension account, so investors tend to reduce equity holdings in the taxable account for precautionary saving purpose and boost equity investments in the tax-deferred account to maintain an optimal portfolio mix. I find that a 10 percentage point increase in the estimated employer matching rate makes investors reduce the average equity proportion in the taxable account by 22 percentage point and boost those holdings in the pension account by 10 percentage point. In contrast, since the employer stock match exposes the households to a riskier situation in the pension account than the cash match, it causes households voluntarily to hold less equity in that account, resulting in an average decrease of 4 percentage point in the equity ownership and 3 percentage point in the conditional equity proportion. Moreover, the policy experiment reveals that a deletion of Social Security taxes and payments makes the pension account the only source of retirement income, so households tend to put a higher proportion of savings in the tax-deferred account, and they are likely to invest conservatively and hold about 25 percent more of pension wealth in relatively safe assets.

The second essay is about company stock investment in 401(k) plans. Company stock investment in 401(k) pension plans has become an important but risky asset in retirement wealth. Previous studies on the determinants of company stock holdings focus on the past stock market performance of company stock, but ignore the characteristics of the retirement plans and individuals, such as company size, employer matches, other pension assets, and financial wealth information. In this study, using the data from Survey of Consumer Finances (SCF), I provide an empirical analysis of the factors that affect company stock holdings in 401(k) plans, by analyzing a broad list of company features, individual characteristics, and financial wealth information. My preferred estimates suggest that, different from general stocks which are sensitive to risk preference and total wealth, the decision of whether to hold company stock is more

likely to be affected by the employer's characteristics and the availability of other investment opportunities. Individuals who work in larger companies and receive more employer matches in the retirement account are more likely to hold company stock in the retirement account, and they are less likely to hold company stocks when the wealth outside the pension account is large and they have other retirement accounts. In addition, I find that the company stock share in 401(k) account is decreasing with pension wealth and total net wealth, which indicates that less wealthy individuals are those who are more exposed to company stock risk.

The third essay analyzes the impact of investment choice on savings in defined contribution pensions. The striking growth defined contribution (DC) pensions have vastly expanded the number of individuals with some discretion regarding their retirement savings. One of the factors that may affect saving decisions is investment choice: namely the ability of the participant to direct the investment of the assets in the pension account. In most studies, people who report that they have control over assets allocation in pension plans do not distinguish the assets between the participant contribution and the employer contribution, but it is common for the employer's contribution to be constrained–often to company stock. In this study, I use the Health and Retirement Study (HRS) to estimate the impacts of unconstrained and constrained investment choices on participant saving levels in DC Pensions. The estimates and results indicate that participants with investment choice contribute over 3 percentage points more of their earnings into the defined contribution plan than people without choice, and people constrained in their investment contribute about 3 percentage points less in their retirement saving account. In addition, I find that male and lower income participants tend to contribute more in a self-directed saving account.

To my parents and beloved husband.

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Chapter 1

Retirement Savings and Portfolio Choices in Taxable and Tax-Deferred Accounts

1.1 Introduction

The growth of Defined Contribution (DC) Pensions (401k, 403b, and IRAs)[1] provides households new choices of which types of assets and how much of each asset to hold in conventional taxable accounts and tax-deferred pension accounts. This problem involves making both an optimal asset allocation decision (i.e. deciding how much of each asset to hold) and an optimal asset location decision (i.e. deciding which assets to hold in the taxable and tax-deferred accounts). Households have the opportunity to save and invest in the pension account on a pretax basis, but their behavior is also affected by the pension account characteristics, such as employer matching policies, liquidity constraints, contribution limit, and transaction costs. Investors not only would like to reduce the tax burden of owning financial assets, but also take advantages of pension

[1]The recent expansion of defined contribution plans in the United States has included Individual Retirement Accounts (IRAs), which are available to all taxpayers with earned income, 401(k) plans, which are employer-provided defined contribution plans available at some firms, 403(b) plans, which are similar to 401(k) plans but are available to employees at nonprofit institutions, and a number of other smaller programs. At the end of the second quarter in 2008, assets in those retirement accounts totaled nearly 8.8 trillion dollars, with US $4.3 trillion in Individual Retirement Accounts (IRA) and US $4.5 trillion in 401(k)-type pension plans.

account design.

This paper investigates households' optimal saving and asset allocation and location decisions in the presence of the employer matching policies and other aspects of pension account design. I estimate a dynamic stochastic model of life-cycle intertemporal consumption and portfolio choice, in which households save and invest in a taxable account together with a tax-deferred pension account. The pension account is characterized by the design of U.S. Defined Contribution plans. I focus on explaining observed household saving and investment decisions over the life time, and analyzing how the employer matching strategy and its interaction with other pension account features influence households' optimal behavior.

This study is motivated by two observations. First, although the asset allocation and location decision is crucial to the wealth accumulation and the welfare of households over the life time, only limited guidance is available. Tepper (1981) and Black (1980) suggest that people should hold all higher-taxed asset (bonds, in the case of the U.S.) in the tax-deferred account to shelter the tax burden of owning financial assets. Only in cases when desired holdings of higher-taxed assets exceed the capacity of tax-deferred accounts can some of them spill over into taxable accounts. These portfolio allocations have acquired the label of "tax-efficient", and have been shown optimal in a dynamic intertemporal choice model (Dammon et al., 2004). However, that advice is sharply at odds with observed portfolio choices of American households, who commonly keep both equities and bonds in each account type, and they often maintain higher equity positions inside their retirement accounts (Poterba and Samwick, 1997; Bergstresser and Poterba, 2004). For instance, as reported in the Survey of Consumer Finances (SCF) from 1992 to 2007, among households with a positive balance in both taxable and tax-deferred accounts, a significant percentage of households have all of their equities in the pension account (29.43%). The survey also shows that investors are more likely to hold equities in the tax-deferred account. There are about 77.09% of the households having equities in the pension account, while only 58.32% of them holding positive equities in the taxable account. The evidence indicates that tax treatment may not be the only explanation of household portfolio problems. Some theoretical studies (Shoven and Sialm, 2004; Huang, 2001; Amromin, 2003; Dammon et al., 2004) also suggest that other aspects of the household decision-making environment must be taken into account

in order to explain the observed patterns of portfolio choices.[2]

Second, the employer matching policy has been shown empirically important in the problems of retirement saving and portfolio choices. In most types of defined contribution plans, employers usually make some contributions to match the employees' savings in their individual retirement accounts, which is considered to be one type of employees' benefits. And in some DC plans, mainly 401(k) type, the employer match is in the form of company stock instead of cash. Company stock is considered to be a more risky investment because it is positively correlated with labor income risk. Therefore, a worker with company stock investment in the pension accounts may face the risk of losing job and the loss of retirement wealth at the same time. Those employer matching strategies, especially in the form company stocks, tend to affect the returns and riskiness of the pension accounts, and therefore the saving and investment behavior of the households. Engelhardt (2004) suggests that employer matches tend to increase the retirement savings of the participants in the pension account, and Benartzi (2001), VanDerhei (2002), Liang and Weisbenner (2002a), and Papke (2004) also empirically show that individuals with employer matching benefit are more likely to hold equities in the retirement account. However, those account features have not been fully analyzed in a structural model of households' savings and portfolio choices.

In this study, I incorporate the employer matching policies and other pension account characteristics into an intertemporal consumption and portfolio choice model over the life-cycle, where assets are accumulated in a taxable saving account and a tax-deferred pension account. The solution rules suggest that the employer matching benefit in the pension account causes households to increase the tax-deferred savings, resulting in a higher proportion of wealth held in the pension account. Therefore, in the presence of uninsurable labor income risks and imperfect liquidity of pension wealth, borrowing-constraint households would like to hold more safe assets in the taxable account for precautionary saving purpose (Amromin, 2003), and they tend to boost equity holdings in the tax-deferred account to maintain an optimal portfolio mix and enjoy the

[2]Some recent theoretical studies produce a mix holding of equities and bonds in the tax-deferred account by considering tax-exempt investment opportunity, consumption and labor income shocks, and liquidity needs. For instance, Shoven and Sialm (2004) extends the asset set to tax-exempt municipal bonds; Huang (2001) analyzes the borrowing and short-selling constraints and liquidity needs; Amromin (2003) emphasizes the joint importance of uninsurable labor income risk and imperfect liquidity of pension account; Dammon et al. (2004) adds consumption shocks to their model.

higher returns of equity investment. This asset allocation and location strategy ends up with a lower equity investment in the taxable account, but a relative high equity holding in the tax-deferred pension account.

The model is estimated using the data from the Surveys of Consumer Finances (1992 to 2007), and the structural parameters are recovered by the Method of Simulated Moments, which has been used by Garkidis (1998), French (1998), Gourinchas and Parker (2002), and Cagetti (2003) to study consumption, labor supply and retirement behavior problems. Considering the size of this problem, parallel programming techniques as implemented in Message Passing Interface (MPI) are applied to make the problem computationally feasible (Swann, 2000, 2001). The estimated model is used to re-interpret the households saving and investment decision rules over the life time, and to analyze the impact of different pension account designs on households' behavior.

With the pension account features, the fitted model is able to match the observed portfolio age-patterns in both the taxable and tax-deferred saving accounts. I find that equity ownership in the taxable account is increasing with age, from around 25% at age 25 to about 60% right before retirement, while in the tax-deferred account, the equity ownership rate remains at a very high level through out the whole working life. The average conditional equity share among the investors is also slightly higher in the pension account than that in the taxable account. The estimated results show that there are a certain amount of households who only hold equities in the pension account, with all their taxable wealth invested in safe assets (bonds), which is also consistent with the fact observed by the data. This study suggests that the observed household portfolio dynamics in the taxable and tax-deferred accounts are optimal decisions with respect to pension account designs.

In addition to explaining the data, the estimates and results of this study yield the following findings. First, the estimated model suggests that the employer matching strategy makes households boost equity investments in the tax-deferred account and hold more safe assets in the taxable account. I find that the average conditional equity proportion in the pension account is increasing by 10 percentage point after a 0.1 increase in the estimated employer matching rate, while the equity proportion in the taxable account is decreasing by 22 percentage point on average. Moreover, households at different age stages respond differently to employer match changes. It is shown that

young households (age $25-45$) are more sensitive to the change in employer matching policies, yielding an average elasticity of equity ownership with respect to the match rate at 2.6 in the pension account, but older households who are more concerned with retirement wealth are less sensitive to the policy changes, yielding a matching rate elasticity of equity ownership at 0.04 in the tax-deferred investment.

Second, the estimates show that the employer stock match exposes the households to a riskier situation in the pension account than the cash match, so it causes the households voluntarily to hold less equities in the pension account, with an average decrease of 4% in equity ownership and 3% in conditional equity proportions. However, when the risky asset return is positively correlated with labor income shock, the situation is quite different. The precautionary saving concern during the young ages increases the proportion of wealth held in the taxable account and further reduce the equity investment in that account, which in turn results in a even higher concentrated equity holding in the pension account. This result is consistent with the empirical findings in Benartzi (2001) and Liang and Weisbenner (2002a), who show that employer company stock matches cause participants to hold more company stocks in the pension account.

Finally, this model provides a framework to analyze the consequences of transforming the Social Security system to a tax-deferred retirement saving account. I analyze two cases in this study. The first one is to remove the Social Security taxes during the working time and payments during the retirement. The results suggest that households do not change their behavior except during the periods right before retirement. Since the saving limit in the pension account remains the same, a higher proportion of savings is allocated to the taxable account. In the second case, besides removing the Social Security taxes and payments I increase the saving limit in the pension account accordingly. I find that households would like to increase their retirement savings to meet the new limit, which consequently ends up with little wealth in the taxable account. Additionally, as the larger size of pre-tax savings increases the relative importance of pension account to total wealth, households invest conservatively and hold about 25% more of pension wealth in the safe assets.

This paper is related to two main strands of literatures. First, my work builds on previous studies that analyze the dynamic decisions of taxable and tax-deferred investments. Campbell et al. (2001a) studies the interaction between asset choices for retire-

ment savings and taxable accounts. Dammon et al. (2004) and Shoven and Sialm (2004) show that the households have preference of holding taxable bonds (higher-taxed asset) in the tax-deferred pension account. Huang (2001) and Amromin (2003) emphasizes the importance of liquidity needs of the taxable wealth, which may generate a mix holding of equities and bonds in the tax-deferred account. My approach goes beyond those studies by characterizing the pension account designs in the analysis, and estimating a structural model of retirement savings and portfolio choices.

Second, my study extends the discussions of employer matching policies and other pension account designs. Choi et al. (2004) summarizes the pension account features that may influence individuals' or households' behavior. Engelhardt (2004), Benartzi (2001), VanDerhei (2002), Liang and Weisbenner (2002a), and Papke (2004) empirically show the impact of employer cash matches and stock matches on the saving and investment decisions of households. This riskiness of company stock investments is also addressed by Meulbroek (2002), Ramaswamy (2003), Poterba (2003), Campbell and Viceira (1999), Davis and Willen (2000a,b), and Heaton and Lucas (2000). In this paper, I incorporate the employer matching strategy into a structural model of portfolio choices with taxable and tax-deferred investments, and investigate the different effects of cash match and stock match on households' optimal behavior.

The remainder of the paper is structured as follows. Section 2 lays out an empirically tractable dynamic model of optimal household savings and portfolio choices. Section 3 describes the data set and the construction of life-cycle profiles of asset allocation and location. The fourth section introduces the estimation method that is used to recover the structural parameters. In section 5, I present the estimated results, analyze the effects of pension account designs, and explore the consequences of the changes of some parameters. Finally, the conclusion and future extensions are discussed in section 6. Appendices contain more detailed descriptions of the theoretical model, the numerical optimization, and the econometric procedure.

1.2 Model and Numerical Solutions

In this section, I build an intertemporal life-cycle model of optimal consumption and portfolio choice, by incorporating a tax-deferred (pension) savings account together

with a taxable savings account. Households receive stochastic income, and make decisions of how much to consume, how much to save in each account, and how much of each asset to hold in each account. They are confronted with specific characteristics of the retirement account, tax policies on different assets, riskiness in the financial and labor market, as well as uncertainties in life expectancy.

1.2.1 The Model

The model assumes that each household is one decision unit, for most consumption and investment decisions are made jointly by members within one family. The head of the household makes decisions annually starting age 25 and lives until age 85, during which he works the first 40 years. The maximum age $T = 85$ and the retirement age $K = 65$ are set exogenous and fixed. Households derive utility from the consumption of a single good C_t in every period. During the working life, $t = 25, \ldots, K-1$, each household receives a stochastic annual income Y_t, [3] chooses how much to consume, and makes saving and investment decisions in both a pension account (such as 401(k), 403(b), and IRAs) and a conventional taxable account. Their decisions are conditional on the tax and pension account policies. I label the wealth in the pension account as W^P, and that in the taxable account as W^A. When the head of the household retires, he liquids the pension wealth, receives the expected value of retirement payments from Social Security pension system,[4] and consumes those assets until the last period of life.

The features of the pension account make it a special investment vehicle for households, otherwise the investor would be indifferent between putting a dollar into retirement savings or into regular savings. In my model the pension account differs from the taxable account in the following ways. The first difference is tax benefit — the savings and investment gains in the pension account are tax-deferred. So the total wealth of a household during working life, W, is

$$W_t = W_t^A + (1-\tau)W_t^P, t = 25 \ldots K-1. \tag{1-1}$$

[3] Although households do not make an endogenous labor-leisure choice in my model, I interpret the income as labor income, which is related to the saving decisions in the pension account.

[4] Social Security is a public pension system in the United States, which collects taxes during the working life and pays out benefit during retirement. It is a *pay-as-you-go* system. In this study, I treat it as an additional source of retirement income.

where τ is the ordinary income tax rate imposed when the household liquidize the pension wealth. The second difference is illiquid constraint — pre-retirement withdrawal from the pension account is subject to penalty. Without illiquid constraint, tax benefit yielding a higher effective rate of return on retirement savings would cause the household to hold all wealth in the retirement account. I set the penalty of pre-retirement withdrawal as *pnl*, a percentage of the amount withdrawn, and the age at which one can liquidize the pension funds without penalty is the retirement age K.[5] Thirdly, the contributions into the pension account during working life are subject to a upper limit. I define that the savings in the tax-deferred account, s_t^P, cannot exceed a certain percentage of current income, $q \cdot Y_t$, where q denotes the maximal proportion of income could be allocated to the pension account.[6] Fourthly, in most employer-sponsored DC plans, the employer usually match some or all of the employees' contributions. The model assumes the employer will provide some matchings whenever the employee saves a positive amount in the pension account. Those matchings are placed into the tax-deferred account of the employee, and can be invested in many ways. The ratio of the contribution from the employer to that from the employee is defined as matching rate, m.[7] Lastly, there are usually less transaction cost in the pension account than that in the taxable account. Investors have to pay certain transaction fees whenever they trade the assets in the taxable account, but they do not need to pay any fee for the transactions when first enrolled in the pension account, and only slight fees for the future transactions. So I insert a parameter, tr, in the taxable account to capture the transaction costs difference between those two types of accounts.

In addition, the model assumes investors can only trade two types of assets in the

[5]Currently, the age that one can withdraw retirement funds in regular IRA without penalty is $59\frac{1}{2}$. I set it at the retirement age for simplicity.

[6]Most of all employer-sponsored plans impose a upper limit of retirement savings, for instance, 20 percent of pretax earnings. IRAs also have limit on the contributions, but whether those savings are tax deductible depends on many things, such as AGI (Adjusted Gross Income), whether having a employer-sponsored retirement plan, and how much have been saved in those pension accounts. Based on different situations, the contributions in IRAs could range from totally tax deductible to none tax deductible. Therefore, in this study I set the limit to 20 percent of pretax earnings, which is almost the same as the reality.

[7]The matching policies of the pension plans vary a lot from one employer to another. Some of them make matches whenever the employees have some contribution by themselves, the case in my model, while some of them make contributions unconditional on the employee's behavior. The matching rate also varies a lot across employers, from less than 50 percent to over 200 percent. For the purpose of numerical analysis, I choose to build the model under the former condition only, and assume all employers make matches at one level.

financial market, one of which is risk free bond with a pretax return, r^b, [8] and the other is risky stock with a stochastic pretax return, r. The riskless bonds are taxed at the rate, τ^b, which is also the ordinary income tax rate. The total return on equities is comprised of dividends and capital gains. Dividends (and interest payments), d, are realized automatically and are taxed at τ^d, while realization of capital gains, g, is normally distributed, $g \to N(\mu_r, \sigma_r^2)$, and depends on timing choices of the investor. When realized, capital gains are taxed at τ^s.[9] Therefore, the after-tax return on equity is given by, $r^\tau = (1-\tau^d)d + (1-\tau^s)g$.

If the tax rates on different assets were the same, then investors would have the same portfolios in both tax-deferred pension account and regular taxable account. But bond is a higher-taxed security in the United States, so I set $\tau^s < \tau^b$, and $\tau^b = \tau^d = \tau$, as the case in reality. The conventional account taxes all earnings as soon as they are realized, and the pension account defers taxation on returns that accumulate on pre-tax contributions. Consequently, one-period return of \$1 portfolio in taxable account with α_t in equities is,

$$\begin{aligned} R_t &= \alpha_t(1+r^\tau) + (1-\alpha_t)(1+r^b(1-\tau^b)) \\ &= (1+r^b(1-\tau^b)) + \alpha_t(r^\tau - r^b(1-\tau^b)), \end{aligned} \tag{1-2}$$

and the return of a \$1 in pension account with voluntary α_t^P in stocks is given by,

$$\begin{aligned} R_t^P &= \alpha_t^P(1+r) + (1-\alpha_t^P)(1+r^b) \\ &= (1+r^b) + \alpha_t^P(r-r^b). \end{aligned} \tag{1-3}$$

If the employer matching rate is positive and in form of cash, then the return in the pension account can be rewritten as,

$$R_t^P(m) = (1 + \frac{m \cdot s_t^P}{W_t^P + s_t^P}) \cdot R_t^P, \tag{1-4}$$

where $m \cdot s_t^P / (W_t^P + s_t^P)$ is the fraction of employer matchings out of total pension

[8] Another kind of bond is tax-exempt municipal bond, which returns less than risk-free bond. Most empirical data sets do not distinguish the difference between municipal bond and risk-free bond, so I categorize these two as the same in this model.

[9] In the U.S., a distinction is made between short-term capital gains (on equities held less than a year), which are taxed at τ^d, and long-term gains taxed at τ^s. The model assumes that all capital gains are long-term.

wealth. When $m = 0$, the pre-tax return in the pension account is the same as before, $R_t^P(m) = R_t^P$, but when $m > 0$, the return of the pension wealth in Equation 1-3 is augmented by factor $(1 + \frac{m \cdot s_t^P}{W_t^P + s_t^P})$. If the employer matches stocks rather than cash, the return in the pension account can be written as,

$$R_t^P(m) = R_t^P + \frac{m \cdot s_t^P}{W_t^P + s_t^P}(1 + r).$$

In the rest part of this paper, unless otherwise noted, I assume the employer matches are taking the form of cash.

From period K to T, the household retires, and chooses consumption based on initial retirement wealth W_K. Let $\psi(W_K)$ be the expected present value of the utility for the second part of life, as viewed at period K. Then the objective function of each household can be expressed as,

$$\begin{aligned} max_{(C_t, s_t^P, \alpha_t^P, \alpha_t)_{t=0}^{K-1}} E\Big(\sum_{t=25}^{K-1} \beta^t [F(t)U(C_t) + (F(t-1) - F(t))B(W_t)] \\ + \beta^K F(K)\psi(W_K)\Big), \end{aligned} \tag{1-5}$$

where $U(\cdot)$ denotes the investor's utility function, β is the subjective discount factor of the utility, $B(\cdot)$ is the bequest function, and $F(t)$ is the probability of living through period t. I assume that the household's preference can be expressed as the Constant Relative Risk Aversion (CRRA) form,

$$u(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma},$$

where γ is the consumer's relative risk aversion coefficient. In addition, the bequest will be expressed as a function of total wealth only, and has the same coefficient as the utility function,

$$B(W_t) = bq \cdot \frac{W_t^{1-\gamma}}{1-\gamma}.$$

The total wealth at each date is defined as the sum of the taxable wealth and after-tax value of the retirement account balance (see Equation (1-1)).[10] At the time of death,

[10] According to the *reset (or step-up) provision* of the current U.S. tax code, the tax bases of all inherited assets to be costlessly reset to current market prices at the time of the investor's death. This means the assets in the taxable account can be inherited without incurring a capital gains tax. Separating the capital gains of the equities from their dividends turn out to be a hard task in this model, so I will assume that all

the head of household liquidate total wealth and distribute it as a bequest to his beneficiary. For simplicity, the degree of altruism is dictated by the parameter, bq. When $bq = 0$, bequests are accidental, generated by the fact that the life span is uncertain. A higher value of bq indicates a stronger bequest motive for the head of the household. In addition, the value of $F(t)$ is given by

$$F(t) = exp\left(-\sum_{j=0}^{t} \vartheta_j\right),$$

where $\vartheta_j > 0$ is the single-period hazard rate for period j with $\vartheta_{T+1} = \infty$. In practice, the household's annual mortality rates are calibrated to match those for the U.S. population.

The components of wealth evolve as following during working life ($t = 25, \ldots K-1$),

$$W_t = W_t^A + (1-\tau)W_t^P, \tag{1-6}$$

$$\begin{aligned} W_{t+1}^A =& (W_t^A + Y_t(1-\tau-\tau^{ss}) - C_t - s_t^P(1-\tau-pnl \times I(s_t^P < 0, t < K)) \\ & \cdot (1 - tr \times I(\alpha_t > 0)) \cdot R_t, \end{aligned} \tag{1-7}$$

$$W_{t+1}^P = (W_t^P + s_t^P) \cdot R_t^P(m), \tag{1-8}$$

$$s_t^P \leq q \cdot Y_t, \tag{1-9}$$

$$C_t \geq 0, W_t^P \geq 0, W_t^A \geq 0, \tag{1-10}$$

$$0 \leq \alpha_t^P, \alpha_t \leq 1. \tag{1-11}$$

Equation (1-8) describes the wealth accumulation in the retirement account on a pre-tax basis, while (1-7) displays the taxable account, and total wealth is shown in (1-6). In equation (1-7), $Y_t(1-\tau-\tau^{ss})$ is the after tax income which are used for consumption, in which τ is the ordinary income, and τ^{ss} is Social Security tax. s_t^P is the savings in the pension account. In the multiplier of s_t^P , $(1-\tau)$ indicates the contribution in retirement account is pre-tax, and $pnl \times I(s_t^P < 0, t \leq K)$ is the penalty imposed on households when they withdraw the tax-deferred wealth before the retirement age ($t = K$), where pnl is the parameter measuring penalty size and $I(s_t^P < 0, t < K)$ is the indicator. As Social Security public pension is available to everyone, the agents have to

the gains from equities have to be taxed as a bequest.

pay Social Security tax (τ^{ss}) on all the earning,[11] and they will receive benefit payments during retirement. In the taxable account, when household hold equities $\alpha_t > 0$, they need to pay a transaction cost tr, which is a positive proportion of the taxable wealth.[12] In addition, the contribution to the retirement account s_t^P cannot exceed a certain proportion, q, of the current stochastic income Y_t (equation (1-9)). R_t and $R_t^P(m)$ are the stochastic gross return rates earned on assets in the taxable and tax-deferred account respectively, and m in $R_t^P(m)$ is the parameter that measures the size of employer matching rate in the pension account. Furthermore, no borrowing and short selling are allowed in this model (see equation (1-10) and (1-11)).

Throughout the analysis I assume that the ratio of household labor income to their contemporaneous total wealth (taxable plus tax-deferred wealth) prior to retirement can be expressed as a function of age t. This assumption is needed in the numerical analysis to keep the problem homogeneous in wealth and to limit the number of state variables. Define $y_t = Y_t/W_t$, then the stochastic labor income can be expressed as,

$$y_t = e^{f(t)} \cdot u_t,$$

where $f(t)$ is a function derived from age t, taking the form

$$f(t) = l_0 + l_1 \cdot t + l_2 \cdot t^2. \tag{1-12}$$

And u_t is an idiosyncratic transitory shock, taking value 0 with probability $0 \leq pu_t < 1$, otherwise independently and identically log-normally distributed as $N(0, \sigma_u^2)$. The parameter pu_t presents the age-dependent unemployment rate, and defined as

$$pu_t = \frac{e^{(\lambda_0 + \lambda_1 t)}}{1 + e^{(\lambda_0 + \lambda_1 t)}}. \tag{1-13}$$

[11] Thank Anthony Webb for the clarification on this point.

[12] There should be many ways in modeling transaction cost in the portfolio choice problems (see Constantinides (1976) and Liu and Loewenstein (2002) for details). One example would be incurring transaction cost whenever the actual shares held in this period is different from those in the last period, but this method requires the shares of stock in the previous period as a state variable. This change will not only make my model a lot more complicated, but also the normalization procedure in the next section impossible. Another example is to model the transaction cost as a fixed value rather than a proportion of wealth. However, this method, on one hand, is still inaccurate if not combined with the actual trading shares, and on the other hand, is not possible for normalization, which will make this model huge in the computation. Therefore, I decide to treat the transaction cost as a proportion of the taxable wealth in this setting.

Going from the model to the data, I need to make some assumptions about the post-retirement periods. First, different from working life, people after retiring will no longer make contributions to the pension account, and all the special features of pension account that affect household's behavior vanish after retirement. The asset "location and allocation" problem will look different from the working life because of the new uncertainty they face, such as medical expenses and the timing of death. Although these sources of uncertainty are also present to some extent in the last working years, labor income and asset return uncertainties are the dominant source of uncertainty when young. Since I know too little about the form that uncertainty takes after retirement to use this methodology and draw inferences from post-retirement behavior, I assume that households liquid the tax-deferred wealth at the time of retiring ($t = K$), and receive a fixed rate of return on wealth in the rest part of life.[13] Second, as the case in the United States, besides of tax-deferred saving account, most working families will receive Social Security payments after retirement, which is based on the taxes collected during the working time.[14] The amount of payment is calculated from the earning history of each individual and the years of service in the Social Security system. I assume that at each period during retirement each household will receive a fixed Social Security payment, which is equal to a certain percentage of last period permanent income, $h \cdot \overline{Y}_{K-1}$, where h is the replacement rate and $\overline{Y}_{K-1} = E(Y_{K-1})$. Therefore I can define the discounted expected value of all possible retirement payments as $H_K = \frac{1-\beta^{T-K-1}}{1-\beta} \cdot h \cdot \overline{Y}_{K-1}$. [15] This parameter can also capture the payments from employer-sponsored Defined Benefit plans, and some other smaller pension funds. Because of the presence of Social Security system, it would be optimal for some low-income households to hold no wealth in the retirement saving account. Therefore, this part of the model is crucial to explain the empirical fact that a certain proportion of the population do not have any positive savings in the

[13] An alternative way to liquid pension account would be withdrawing tax-deferred wealth as an annuity, or a fixed proportion, such as the reciprocal of life expectancy in Dammon et al. (2001, 2004). However, as long as the rate of return of the taxable account is the same as that of the tax-deferred account, all the withdrawing methods will generate the same answer. Since I assume no asset allocation choice during retirement periods for simplicity, there would be no difference in using any way.

[14] The current tax rate of Social Security is 12.4 percent of pre-tax earnings up to $106,800 in 2009, among which half is charged to employees and the other half to employers.

[15] An alternative way to model Social Security payments is to treat it as an additional saving account with a fixed contribution rate and an implicit rate of return, which can be liquidized at retirement. However, modeling Social Security as a different saving account requires an additional continuous state variable, which is computationally intractable considering the current size of this problem. Therefore I assume a fixed proportion of labor income is set aside by a public sector, and a payment is given when the agent retires.

tax-deferred account.

Then, we can write the Bellman equation for the above maximization problem during working life ($t = 25, \ldots, K-1$) as follows:

$$V_t(W_t^A, W_t^P, Y_t) = max_{(C_t, s_t^P, \alpha_t, \alpha_t^P)}(e^{-\vartheta_t}U(C_t) + (1-e^{-\vartheta_t})B(W_t) + e^{-\vartheta_t}\beta E_t[V_{t+1}(W_{t+1}^A, W_{t+1}^P, Y_{t+1})]),$$

subject to equations (1-6)–(1-11). When $t = K-1$, the last period of working, the value function of the next period is defined as,

$$V_K(W_K^A, W_K^P, Y_K) \equiv V_K(W_K, 0) = \psi(W_K),$$

where

$$W_K = W_K^A + (1-\tau)W_K^P + H_K.$$

and $\psi(W_K)$ is the expected present value of the utility for the second part of life as defined above. A complete description of the retirement value function is provided in the Appendix $A.1$.

The setup of this model combined with the particular choice of retirement value function makes the problem homogeneous of degree $(1-\gamma)$ in the total wealth (i.e., the value of the taxable account plus the after-tax value of the retirement account). I simplify the optimization problem by normalizing by the household total wealth W_t. Let $p_t = W_t^P(1-\tau)/W_t$ be the fraction of the investor's total wealth that is held in the retirement account, $s_t = s_t^P/W_t$ be the ratio of contribution in pension account to the total wealth, $c_t = C_t/W_t$ be consumption-wealth ratio, and let $y_t = Y_t/W_t$ be the income-wealth ratio as previously defined. The detailed steps of normalization are explained in Appendix $A.1$ and $A.2$.

After normalizing by total wealth, the household's intertemporal consumption and portfolio problem involves the following control variables during working time: the consumption-wealth ratio, c_t, the savings-wealth ratio in the pension account, s_t, the fraction of taxable wealth allocated to equity, α_t, and the fraction of tax-deferred pension wealth allocated to equity, α_t^P. The relevant state variables for the normalized problem are the fraction of the household's incoming total wealth that is held in the retirement account p_t, income-wealth ratio y_t and age t. After retiring, the consumption-

wealth ratio c_t is the only control variable, and age is the state variable. Then the above problem can be solved numerically from the last period of life. Since the size and complexity of this problem implie heavy computational demands for the estimation process, I will follow Swann (2000, 2001) in solving this type of problem using parallel programming methods as implemented in the Message Passing Interface (MPI). The detailed solution method is explained in the Appendix $A.3$.

1.2.2 Numerical Solutions of Optimal Choices

After solving this model numerically using the baseline parameters,[16] I have discovered the following properties of optimal household saving and investment decisions that stem from different wealth and income levels:[17]

- The saving in the tax-deferred pension account (s_t) is increasing with normalized income level (y_t). Because of the existence of labor income shock and penalty for early withdrawal, the retirement savings in the pension account can be as low as zero when normalized income is small, and as the pretax saving cannot exceed a limit ($q \cdot y_t$), the saving constraint in the pension account is always binding when normalized income is sufficient high. In addition, when normalized income is low (especially unemployed) and pension wealth accounts for a substantial proportion of total wealth, it is optimal for households to withdrawal a positive amount from retirement account to fund current consumption.

- In the case of a relative low pension-wealth ratio (p_t), households have sufficient wealth in the taxable account for regular consumption needs. Since bonds have a relative high tax burden, it is optimal to hold taxable bonds in the tax-deferred account, and equities in the taxable account. As the normalized income increases, more wealth are held in the taxable account, and the optimal equity proportion in the taxable account increases. Because of the prohibition on borrowing, the proportion of equity in the taxable account is bounded above by 100%, so equities will spill over to tax-deferred account when income is sufficiently high. This portfolio mix is tax-efficient.

[16] Please refer to Table 1-1 and 1-2 for a detailed description of benchmark parameters.

[17] The policy rules are derived by assuming that there is no employer matching benefit ($m = 0$) and no transaction costs difference between taxable and tax-deferred account ($tr = 0$).

- When the fraction of wealth in the pension account is high, there is relative low level of wealth held in the taxable account. Under the consideration of labor income uncertainties and illiquid constraint of pension wealth, households tend to have precautionary savings and hold safe assets (bonds) in the taxable account. Since households try to maintain an optimal overall portfolio mix, their equity holdings in the pension account increase correspondingly, thus resulting in a tax-inefficient portfolio. This phenomenon is more apparent when the normalized income is low, and diminishes when households have a sufficiently high income level.

- From the life-cycle prospective, young households, who expect to have a longer working life, are more likely to have precautionary savings and hold less equities in the taxable account. In the dynamic solutions, a higher level of taxable wealth is needed for young households to hold equities in the taxable account than that for old households.[18]

Based on those features of the policy rules, the model will be able to generate wealth accumulation and portfolio choices over the life time. However, the realist household behavior also depends on the pension account characteristics, such as the employer matching rate and the transaction costs on equity trading. In the next several paragraphs, I will discuss the role of those pension account designs in shaping households' saving and investment decisions.

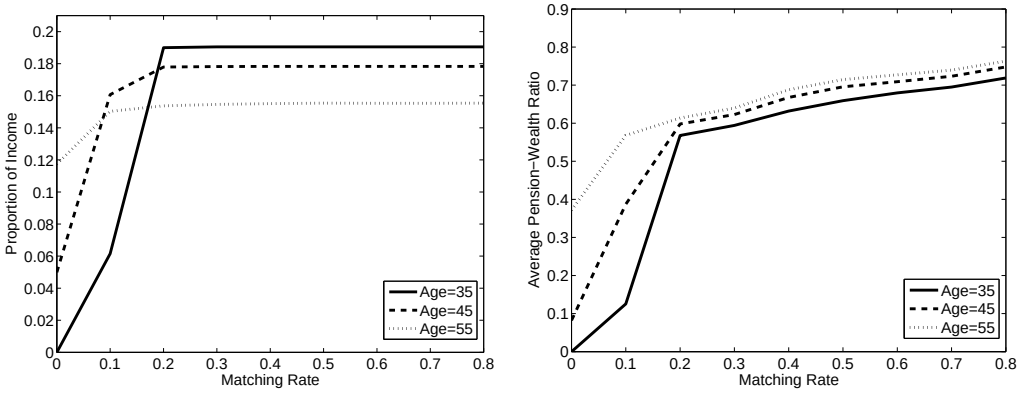
One of the critical policies that affect household decisions is the employer matching strategy. As an important element in the employee's pension package, the employer matching rate are empirically tested to have substantial impacts on household saving and portfolio choices (see discussions in Engelhardt (2004), Benartzi (2001), VanDerhei (2002), Liang and Weisbenner (2002a), and Papke (2004)), but its effect is not clear in a dynamic choice model. I am therefore interested in assessing the effect of changes in matching rate (m) on the retirement saving and asset allocation and location decisions.

To investigate the impact of parameters on the pattern of saving and portfolio choices, I generate a number of simulated policy rules over the life-cycle for a given

[18]For instance, households at age 35 will hold positive equities in the taxable account only when the fraction of wealth in the pension account is lower than 0.5, while households at age 50 will hold equities in the taxable account when the pension-wealth ratio is not higher than 0.9.

set of parameters and record the average level of pretax savings in the pension account and the distribution of equity investment in both taxable and tax-deferred accounts, and then I report the behavior changes at three age periods, $t = 35$, 45, and 55.[19] Figure 1-1 illustrates the effect of changes in employer matching rate on retirement saving decisions, with panel (a) displaying the saving rate in the pension account and panel (b) the fraction of total wealth held in the pension account. As shown in Figure 1-1(a), an increase in the matching rate makes household increase the proportion of income allocated in the pension account. The effect on saving rate is larger when m increasing from zero to 0.2, and since the savings are bounded by upper limit, the effect becomes quite small after 0.2. Figure 1-1(b) shows the effect of changes in employer matching rate m on pension-wealth ratio. The fraction of wealth held in the pension account increasing in m. The increased proportion of wealth in the pension account includes two components, one of which is the increase of households' own tax-deferred savings (Figure 1-1(a)), and the other is the increased contribution from the employers. In addition, the marginal effect (slope) of matching rate on tax-deferred savings and pension-wealth ratio is larger for young households than that for old ones, which may reflect the fact that the purpose of young households' pretax saving is to enjoy the pension-favored benefit, so they are more likely to be affected by policy changes.

Figure 1-1: The Role of Employer Matches in Retirement Savings



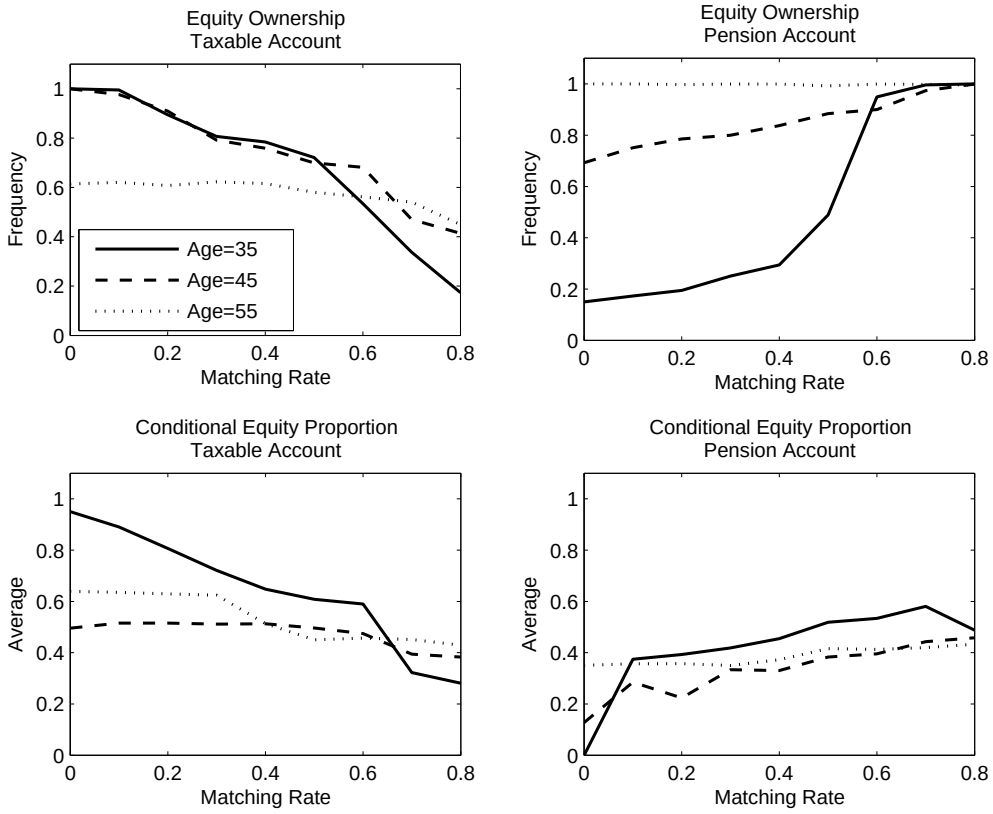
(a) Retirement Saving Rate (b) Pension Wealth Ratio

Besides saving behavior, the employer matching policies also have significant impact on asset allocation and location decisions. Figure 1-2 illustrates the effects of changes in employer matching rate on equity holdings in both taxable and tax-deferred

[19] All parameters, except for m, are set as those in Table 1-1 and 1-2.

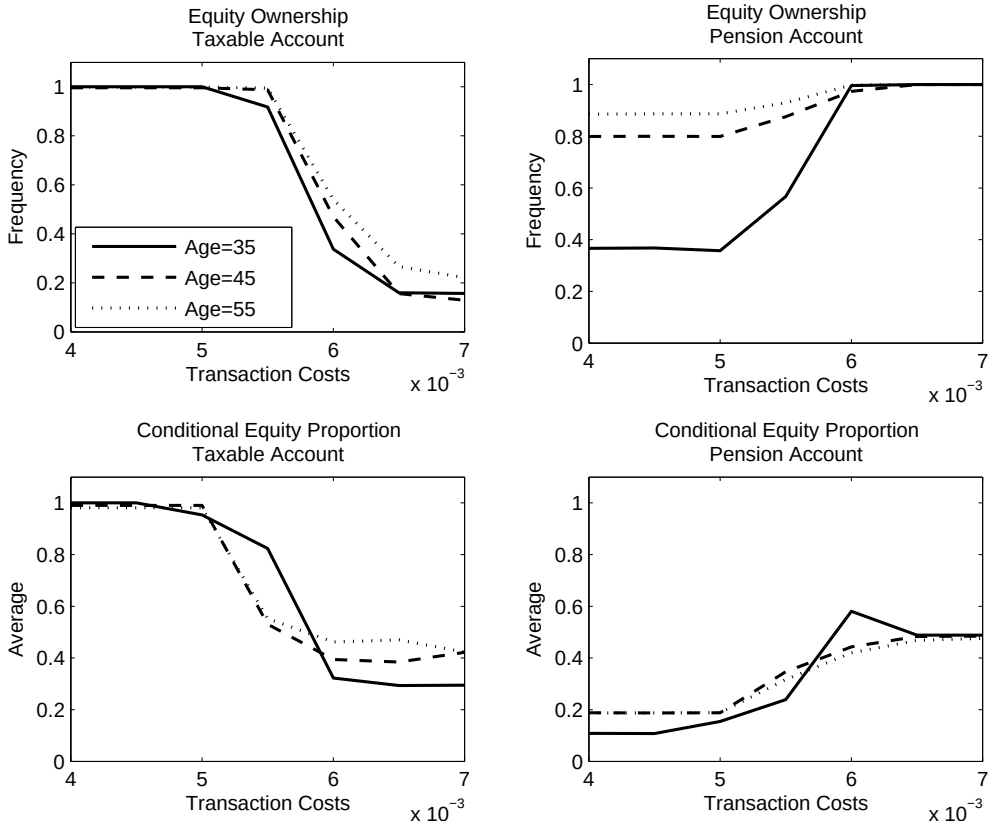
account for different age groups. When there is no employer matches ($m = 0$), the figure shows that households tend to hold most equities in the taxable account for that equities are much less valuable when held in the pension account. However, when employer matches are positive, the optimal equity holding in the taxable account decreases with matching rate and the equity investment in the pension account increases correspondingly. This change can be explained as a consequence of the change in saving behavior. As the employer matches increases, a higher proportion of income are allocated to pension account, resulting in a higher fraction of wealth in the pension account. Therefore two implication can be derived: (1) A lower level of taxable wealth, interacted with labor income shocks and illiquid pension wealth, makes households reduce equity investment for precautionary saving motives; (2) To enjoy the higher returns from equity investment and to maintain an optimal portfolio mix in overall asset holdings, households tend to hold more equities in the pension account. Similarly as saving behavior, the effect of employer matching rate on asset allocation and location decisions is stronger for young households.

Figure 1-2: The Role of Employer Matches in Portfolio Choices



In addition to employer matches, the other pension account design that has impact on portfolio choices is transaction costs. The transaction cost parameter (tr) which is imposed on the taxable but not the tax-deferred investment captures the transaction cost difference in those two types account. A higher value of tr indicates a larger difference in the transaction fees of taxable and tax-deferred equity investment. Since the taxable account has a higher cost in the equity trading than the tax-deferred account, an increase in tr will decrease the equity holdings in the taxable account and increase those investment in the pension account accordingly. This effect is displayed in Figure 1-3. Although the transaction costs parameter has a similar role in the portfolio decisions with employer matching policies, they are different in two important ways. First, employer matching rate significantly influence the household retirement saving decisions, while transaction cost does not. Second, the marginal effect of transaction costs on portfolio choices is similar across different ages, but the effect of employer matches are more prominent for young households (compare taxable investment in Figure 1-2 and 1-3). Therefore, the transaction fees in the taxable account is crucial to explain the relative lower equity investment in the taxable account of the older households .

Figure 1-3: The Role of Transaction Costs in Portfolio Choices



The numerical solutions illustrate a preference of holding equity in the tax-deferred pension account and taxable bonds in the taxable account under the condition of employer matching policies and other pension account characteristics. I also have discussed how the overall asset allocation depends upon the fraction of total wealth held in the pension account, income-wealth ratio and ages. In the results section, I will investigate the estimated time-series profiles of the households' optimal saving and portfolio allocation decisions using simulation analysis.

1.3 Data

The data used in this study come from the latest Surveys of Consumer Finances (SCF), conducted in 1992, 1995, 1998, 2001, 2004 and 2007. The SCFs are sponsored by the Federal Reserve Board and have been conducted by survey research professional at the University of Michigan and the National Opinion Research Center triennially since 1983. Because of limitations in the pension investment questionnaire, I choose the waves starting in 1992. There are 3906, 4299, 4305, 4442, 4519, and 4418 households, respectively, in the surveys studied here. Since this study focuses on the working life of households, I drop all households with male heads younger than 25 and older than 70. The total number of households in the analysis becomes 21379.

The Survey data in the SCFs are the most complete data source on households' balance sheets in the United States. The surveys ask a wide array of questions on every aspect of the household financial situations - amount and type of liquid and illiquid assets, asset location and allocation, pension plan characteristics, sources of earnings, demographic information, and so on.[20] Of particular value for studies of household portfolio composition is the fact that the SCF oversamples wealthy households, which tend to have richer portfolio structures. Each survey makes available a set of sampling factors that allow one to re-weight the sample to produce population statistics. Unless otherwise noted, all descriptive statistics utilize population weights. In addition, I put all data into real 1992 dollars using Consumer Price Index (CPI) employed by the SCFs

[20]The SCFs attempt to uncover precise composition of household financial portfolios. Unfortunately, in the surveys conducted in 1992, 1995, 1998, and 2001, information on allocations to narrowly defined asset classes exists only for funds kept in taxable investment accounts. By contrast, the composition of holdings in tax-deferred retirement accounts, both individual (like IRA and Keoghs) and employer-sponsored (i.e. 401k, 403b) has to be inferred from categorical responses. I applied a mapping similar as Amromin (2005) to construct the retirement portfolios in those years.

on all the surveys. [21]

I construct measures of wealth and portfolios that match the concepts in the theoretical model. I define investable household wealth as total quasi-liquid financial assets that can be explicitly allocated between investments with equity- or bond-like properties. The taxable account includes nearly all financial instruments, such as directly held bonds, stocks, mutual funds, and saving accounts. It specifically excludes checking accounts on the grounds that they are used primarily for transaction purposes, as well as housing, proprietary business wealth, and human capital wealth. The tax-deferred retirement wealth consists of employer-sponsored defined contribution plans (i.e., 401k, 403b) and individual retirement accounts (such as IRA and Keoghs), but it omits imputed values of future guaranteed pension income (Social Security, and defined benefit plans). In order to obtain a high quality sample that has the required information, I further drop 1156 households that report no financial wealth, since the solution of my model requires a normalization over total wealth. Thus among all the observations in sample (20223 households), there are 13243 respondents (65.5 percent of the whole sample) having positive taxable wealth and positive pension wealth,[22] and this is the sample of those who can make asset allocation and location decisions in taxable and tax-deferred accounts.

In addition, the definition of "bonds" and "stocks" is clearly important too. Typically, "bonds" have been interpreted to be corporate, municipal, and government bonds traded on financial markets.[23] Since I focus on the asset location and allocation problem, I augment this set of assets with money market and saving accounts which face the same tax treatment as conventional bonds, as described in Amromin (2005). Consequently, the share of "equities" held in taxable accounts is defined as the sum of directly held stocks and stock mutual funds divided by total investable taxable wealth, while the

[21] The detailed explanations of the inflators can be found in SCFs bulletin (e.g. *http://www.federalreserve.gov/pubs/oss/oss2/2007/scf2007home.html#bullart*). Note that since some of the variables in the theoretical analysis are normalized values by total wealth, the inflation-adjusted step may not be needed.

[22] Among the sample in analysis, 6870 households report having no pension wealth. This is the sample of those who do not have tax-deferred savings, or have liquid the tax-deferred balance. There is another 110 households only have positive wealth in the pension account, which could be the case that those households consume up the taxable wealth in a certain period due to short of income or savings. I consider both of the cases could be explained by the theoretical model, so I leave those respondents in the analysis.

[23] I exclude the tax-exempt municipal bonds for that they have different tax treatment with taxable bonds.

share of "equities" in tax-deferred account would be the sum of stocks and stock mutual funds divided by total retirement wealth. Furthermore, the labor income is defined as the sum of all pre-tax wages earned within a family. If the member of a household is self-employed, the labor income is the earnings from business. Since the theoretical model treat each year as a time period, all the empirical variables are evaluated on a annual basis.

In the estimation, I use the average of life-cycle portfolio choices in both taxable accounts and tax-deferred accounts as the sample moments. Generally speaking, those average age-profiles of portfolio choices can be constructed by averaging the data across households at each age. However, it is not possible to ignore cohort and time effects, because asset investments have changed with generations and time periods. In order to reconstruct the household portfolio data uncontaminated by cohort and time effects, I apply a method similar to that described in Gourinchas and Parker (2002). In particular, four profiles are estimated using household level data from age 25 to 64: the equity ownership in the taxable account; the equity share in the taxable account, conditional on flows to equity being positive; the equity ownership in the tax-deferred account; [24] and the conditional equity share in the tax-deferred account. For each of these profiles, an equation is regressed over a list of age, time, and cohort indicators. As discussed in (Ameriks and Zeldes, 2004), it is not possible to separately identify the linear component of the age, time, and cohort effects. Due to the fact that individuals who witnessed poor stock market returns early in their life would choose to be less exposed to stocks later in the life, I choose the identifying restriction such that cohort effects are the history of financial returns experienced during the lifetime and captured by the average real stock return experienced by the head of the household from age 15 to age 25 (age $15-25$ return). [25] Then the life-cycle portfolio choices are constructed by removing the time and cohort effects. In practice, the ownership equations (based on a dichotomous choice variable) are estimated using a probit procedure and the portfolio share equations (based on a continuous variable) using simple OLS.[26] Other age-dependent pro-

[24]The equity ownership in the tax-deferred account is evaluated based on the condition that the tax-deferred wealth is positive.

[25]This formulation assumes that cohort effects are not important for the evidence in portfolio choices. The effects of age and time may be sensitive to this assumption.

[26]Specifically, each dependent portfolio decision is regressed on a complete set of age dummies, time dummies (less year 1992), cohort indicators (age $15-25$ returns), and a retirement dummy that is equal to 1 if the respondent is retired. With these estimates, a predicted value is obtained by setting the time and

files, such as pension-wealth proportion and income-wealth ratio, are also constructed by the same method.

The reconstructed life-cycle (working time) asset location and allocation profiles are displayed in Figure 1-4. The evidence is consistent with that observed in other studies (Poterba and Samwick, 1997; Bergstresser and Poterba, 2004; Amromin, 2005) — households commonly keep both equities and bonds in tax-deferred and taxable accounts, and they often maintain a higher equity position inside the retirement accounts. The top two graphs show the proportion of the population with positive equity holdings in each type of account. It can be clearly observed that the equity ownership in the taxable account is increasing with age, while that in the retirement account remains at a higher level throughout the life time. The lower two graphs illustrate the average equity share conditional on ownership in both accounts. The average proportion in the taxable account is slightly increasing with age, while that in the retirement account is slightly decreasing with age. This is the version of sample moments used in the structural estimation discussed in the next section.

1.4 Estimation

I recover those structural parameters of the theoretical model using the Method of Simulated Moments (MSM). I assume that households start off the retirement saving with an initial pension-wealth ratio, and for each set of parameter I compute the policy rules that solve the dynamic problem and use these rules to generate simulated portfolio choices over the life-cycle. Then at each iteration of the parameters I construct a measure of distance between the observed and simulated moments, namely the age-dependent saving and investment behavior in the taxable account and tax-deferred account. The parameter estimates of the theoretical model are those that minimize this distance.

On thing that needs to be noted before the discussion of estimation process is that some of the parameters are pre-determined in the model. This is due to the observable features of those parameters and the fact that they may not be identified separately from one or another. Table 1-1 provides a summary of those determined parameters. First, I

retirement dummies to zero, and the cohort indicator to a average value (10 percent, estimated from the historical data). The retirement variable is removed because this study focuses on the working population that have labor income and make saving decisions. Thus the constructed portfolio data represent the behavior of the observed households facing the financial market like that in 1992, and not retired.

estimate the riskless return on taxable bonds from the average real return on Moody's AAA Corporate Bonds, and the risky stock returns from the S&P500 index. Over the period January 1990 to December 2007, which is the duration of the data used in the empirical analysis, the pre-tax interest rate on the riskless taxable bond is $r^b = 7\%$ per year; the dividend yield on the stock index is $d = 2\%$ per year; and the annual capital gains return on the stock index is nominally distributed with a mean of $\mu_r = 9.81\%$ and standard deviation of $\sigma_r = 16.9\%$. Because the pre-tax expected return on the stock index is given by $\bar{r^s} = (1+\mu_r)(1+d) - 1$, the annual pre-tax equity risk premium is 5%. Because I use the most recent financial information, this equity risk premium is relatively low compared to the historical average risk premium of about 8%, but it is consistent with most of recent studies (Dammon et al., 2004; Shoven, 1999). In addition, I assume that the tax rate on dividends and interest is, $\tau^d = 36\%$, the tax rate on realized capital gains is $\tau^s = 20\%$, and Social Security tax is $\tau^{ss} = 6\%$. In reality, the tax rate on income and capital gains is progress, but I will simplify it to a flat rate in the analysis, and this rate is about the actual tax paid by middle-class population. I further set the cap of retirement savings at the rate $q = 20\%$, and the penalty on pre-retirement withdrawal as $pnl = 10\%$. Both of these two values addict to the true values in the real life.

Table 1-1: Pre-determined Parameter Values

Parameters	Notation	Base-line Value
Asset Returns		
Riskless pre-tax return	r^b	7.0%
Dividend yield on equity	d	2.0%
Expected capital gain return on equity	μ_r	9.81%
Standard deviation of capital gain return	σ_r	16.9%
Tax Rates		
Dividend (Bonds) tax rate	τ^d	36%
Capital gain tax rate	τ^s	20%
Social Security tax rate	τ^{ss}	6%
Retirement savings		
Cap of retirement saving rate	q	20%
Penalty on pre-retirement withdrawal	pnl	10%

The rest of the parameters will be recovered from estimation. I assume all households start off at age $t = 25$, with a pension-wealth ratio p_{25} drawn from a lognormal distribution, $ln(p_{25}) \sim N(\mu_p, \sigma_p^2)$. The parameters to estimate are then the followings:

Retirement Saving Parameters $(m, tr, h, \mu_p, \sigma_p^2)$, Preference Parameters (β, γ, bq),and Labor Market Parameters $(l_0, l_1, l_2, \sigma_u, \lambda_0, \lambda_1)$. The parameters of labor income process, such as the marginal effect of time (l_0, l_1, l_2) and labor income shocks $(\sigma_u, \lambda_0, \lambda_1)$, can be identified from the aggregate income profile.[27] Given the wage distribution, asset stochastic returns and life time uncertainty, the parameters of a a standard intertemporal consumption and portfolio choice model can be identified by the asset levels and portfolio choices over time, including discount factor β, risk aversion rate γ and bequest factor bq (see Gourinchas and Parker (2002)) and Cagetti (2003)). In addition, the data of separate wealth accumulation paths in the taxable and tax-deferred accounts can identify structural parameters of retirement saving propensities, such as initial wealth distribution (μ_p, σ_p^2), and the fraction of Social Security payment to total wealth level h, which is a crucial income to households who do not have significant assets in the pension account. Furthermore, the pension account characteristics, such as employer matching rate m and the level of transaction cost in equity trading tr, could be identified from their unique effects on the observed saving and the asset location and allocation decisions in each year during working time. Specifically, although both employer matching rate and lower transaction cost in the tax-deferred pension account tend to increase equity holdings in that account, their effects differ in two important ways: (1) while transaction cost does not show clear effect on the saving behavior, the employer matching policies additionally influence pre-tax saving decisions, which in turn affect the share of total wealth held in the pension account; (2) when households are getting older, the role of employer matching strategies in the retirement saving and investment decisions becomes smaller, but the impact of transaction costs remains the same as that for young households.[28] Therefore, the parameters m and tr can be identified by the dynamic data of saving and portfolio choices.

Given the value of those parameters, one can simulate the model for a large number of agents and compute the distribution of choice variables for each agent at age t. One way to estimate the parameters is therefore to choose the ones that generate a simulated distribution that matches some aspects of the empirical distribution. In particular, the moments used in this estimation are the cell-by-cell expectations for the following

[27] Ideally, one can identify the income transition parameters with a complete record of individual earnings over time. Although I do not have a longitudinal data, I can still estimate the wage distribution at each age by the cross-section observations.

[28] See detailed discussion about Figure 1-2 and 1-3 in section 2 .

distributions over 40 years: the equity ownership probability and the conditional equity share in the taxable account, the equity ownership probability and the conditional equity share in the tax-deferred account, and the fraction of wealth held in the pension account and income-wealth ratio distribution. [29]

Thus, there are $J = 240$ (6×40 years) moments and $N = 14$ parameters in the estimation. Let the parameter set be denoted by θ, and the observation of each moment j for household i by ζ_i^j, $j = 1, \ldots, J$. I seek to estimate the model from the following moment conditions:

$$E[\zeta_i^j - \hat{\zeta}^j(\theta_0)] = 0,$$

where θ_0 is the true parameter vector, and $\hat{\zeta}^j$ is the predicted counterpart.

Therefore the estimation procedure is then a method of simulated moments (MSM) (see details in Pakes and Pollard (1989) and Duffie and Singleton (1993)) that minimizes over θ:

$$S(\theta) = g(\theta)' W g(\theta), \tag{1-14}$$

where $g(\theta) = (g_1, \ldots, g_J)'$, with the jth element as,

$$g_j(\theta) = \frac{1}{I_j} \sum_{i=1}^{I_j} \zeta_{i,j} - \hat{\zeta}_j(\theta), \tag{1-15}$$

where I_j is the number of observations for the jth moment. W in equation (1-14) is a positive definite weighting matrix, which can be chose so that the MSM estimator $\tilde{\theta} = argmin[S(\theta)]$ is both consistent and asymptotically normally distributed (see Gourinchas and Parker (2002) and Cagetti (2003)).

In practice, I simulate life-cycle portfolio profiles by generating a sequence of 5000 income processes and risky asset returns over 40 years, and computing in each year the associated asset allocations in each type of account. Once the optimum is found, the asymptotic standard errors are evaluated numerically using the gradient of the moment vector. Considering the size of this problem, parallel programming techniques as implemented in Message Passing Interface (MPI) are applied to make the problem computationally feasible. The extensive explanation of the MSM estimator, the deriva-

[29] Because of the lack of the information in the surveys, consumption-wealth ratio and saving-wealth ratio cannot be used as moments in the estimation. The state variables moments, pension-wealth ratio and income-wealth ratio, are taken in the estimation to capture the saving behavior.

tion of the standard error, and the procedure of parallel programming are provided in the Appendix $A.4$.

1.5 Results

In this section, I first estimate the model for the average household and discuss the implications of the fitted structural model for retirement saving behavior and portfolio choices. And then, I turn to the results of the characteristics in the tax-deferred pension account, and evaluate the impact they have on the households' behavior. Lastly, I analyze the consequences of household behavior that are caused by removing the Social Security tax and payments.

1.5.1 Estimation Results

The results of estimating the structural model are shown in Table 1-2, and the associated household portfolio choices are displayed in Figure 1-4. The parameter estimates comprise of those that characterize retirement savings, utility and bequest functions, and labor income process.

The estimated parameters of retirement savings are shown in the top panel of Table 1-2. The pension account characteristics are the most important factors in this study, which are considered to have significant impact on households' saving decisions and portfolio choices. Those features of retirement saving accounts are captured by two parameters, employer matching rate (m) and transaction cost (tr). The employer matching rate is estimated at 0.6768, which can be interpreted as one dollar retirement saving by the employee is associated with 67.68 cents contribution from the employer. It is worth noting that the estimated employer matching rate is within the reasonable range. According to the Survey of Consumer Finances, the self-reported employer matching rate[30] by the households has a mean of 0.534, with a standard deviation of 2.484. In addition, Engelhardt (2004) also show similar evidence from the Health and Retirement Study (HRS). By using the Summary of Plan Description in HRS, he shows that about 43% of the 209 employer-sponsored defined contribution plans have a matching rate at

[30]Since employers differ a lot in the matching policies, I simply define the employer matching rate as the ratio of employer's contribution to that of the employee's.

Table 1-2: Structural Estimation Results

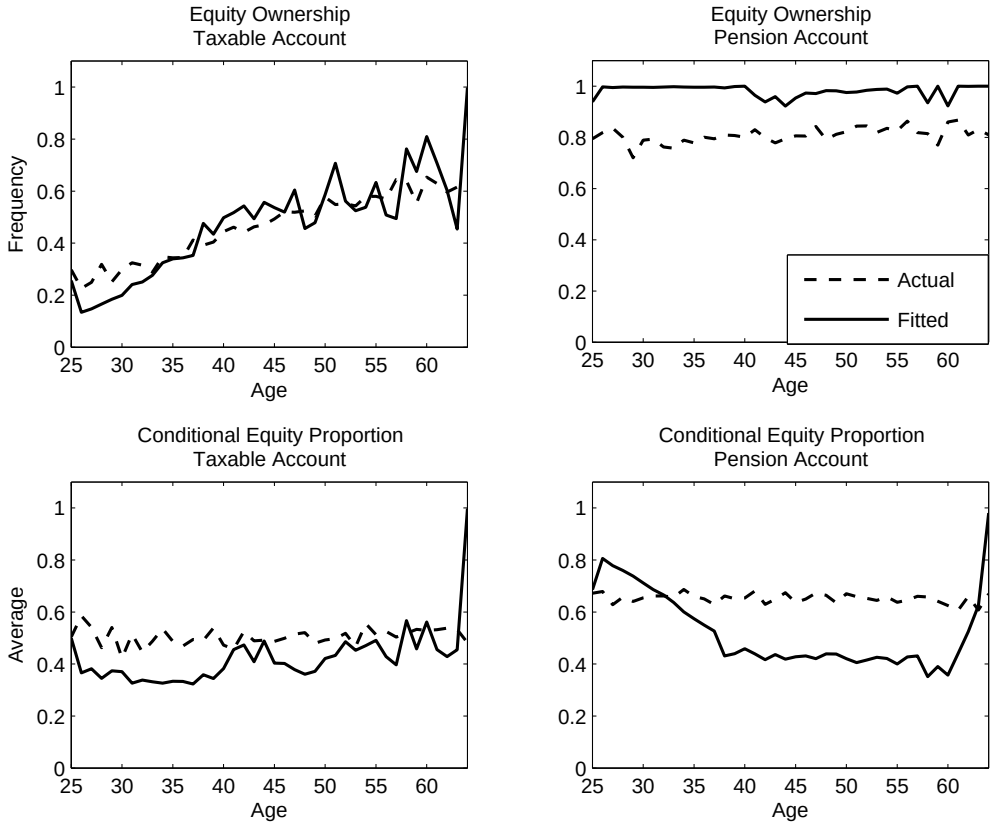
Parameters	Notation	Coef.	(Std.Err.)
Retirement Savings			
Employer matching rate	m	0.6768	(0.0510)
Transaction cost (percentage of taxable wealth)	tr	0.0063	(0.0004)
Replacement Rate (Social Security payment)	h	0.5163	(0.0051)
Initial pension-wealth ratio, Mean	μ_p	−0.6412	(0.0477)
Initial pension-wealth ratio, S.D.	σ_p	0.5490	(0.0449)
Utility and Bequest Functions			
Discount factor	β	0.9838	(0.0739)
Relative risk aversion	γ	3.9607	(0.2811)
Bequest parameter	bq	0.0888	(0.0067)
Labor income equation			
Constant	l_0	6.9976	(0.5595)
Coefficient of age	l_1	−0.1328	(0.0085)
Coefficient of age^2 $\times 100$	l_2	0.0512	(0.0038)
Base unemployment rate	λ_0	−3.0505	(0.1925)
Unemployment rate growth$\times 10$	λ_1	−0.0080	(0.0005)
S.D. of income shock	σ_u	0.4552	(0.0306)
Criterion Function[1]	χ^2	48.1174	

[1] Note: The last row reports a test of the overidentifying restrictions distributed as Chi-squared with 226 degrees of freedom. The critical value at 5% is 262.07.

0.5, which cover 38% of all the individuals in analysis, and additional 35% of those plans provide a matching rate ranging from 0.51 to 1.00, which cover 42% of all the respondents. The estimate of the employer matching rate in this study shows the average level that the households may face when they make saving and portfolio decisions.

Besides employer matching rate, the transaction cost is also an important factor in household portfolio decisions. The estimated transaction cost parameter is about 0.0063, which shows the size of fees that incurred whenever the equity holdings in the taxable account is positive. Since this factor is only imposed on the taxable account but not on the pension account, it captures the transaction costs difference between those two types of accounts. Therefore, accurately speaking, the estimate indicates that households pay 0.63% of their taxable wealth more as transaction fees when they make equity trading in the conventional taxable accounts than that they pay in the tax-deferred accounts. In particular, for instance, if an agent trades 100 dollars stocks in the pension account without paying any fees, he has to pay 63 cents as transaction fees when he make the trading in the taxable account. Based on the reality, although different transaction companies charge different fees, this estimate is in the reasonable range of

Figure 1-4: Portfolio Choices over the Life-Cycle



actual data.[31] According to the Division of Investment Management, the expense ratio of 401(k) mutual funds (management fees divided by overall value) is about 0.4% lower than that outside 401(k) plans.

In addition to the tax-deferred retirement saving opportunity, the households can also receive retirement benefits from Social Security, the public pension system in the United States. The estimated replacement rate for Social Security payment is about 51%, which suggest that the average household receive an income of 50 percent of their last period income during retirement. [32] Moreover, the procedure also give an estimated distribution of the initial pension-wealth ratio, which is log-normally distributed as $N(\mu_p = -0.6412, \sigma_p^2 = 0.5490^2)$. This distribution implies that the mean of the ratio of pension wealth to total wealth, $exp[\mu_p + \sigma_p^2/2]$, is about 0.612, a little higher than the mean level reported by the Survey of Consumer Finances, which provides a average pension-wealth ratio of 0.433 for households with positive balance in the pension

[31] For example, Fidelity charge a $\$8 - \$19.95$ flat commission for each trade in regular taxable account. E∗TRADE also has a fee ranging from \$6.99 to \$12.99 per trade.

[32] The actual replacement rate in Social Security varies across different income group. The low-income people can get a replacement rate as high as 65%, while the high income group can receive as low as 30%. In this simplified model, I only estimate an average level.

account.

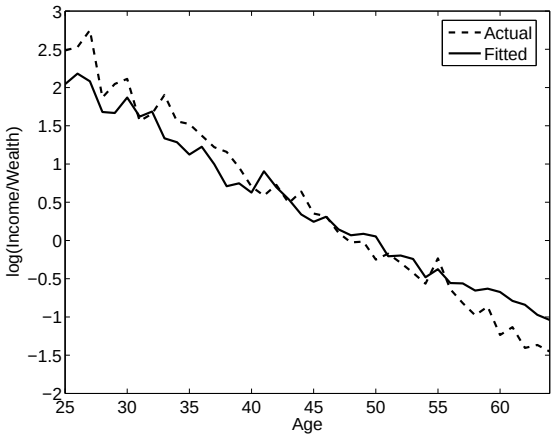
The second panel of Table 1-2 shows the estimate of parameters in the utility and bequest functions. The discount factor (β) is estimated at around 0.98, the risk aversion rate at a level just below 4.0, and the bequest parameter less than 0.1. The results are consistent with the findings in Cagetti (2003). The higher discount factor in this study (compared with Gourinchas and Parker (2002)) indicates a relative higher degree of patience for the households, who are willing to save more and earlier for retirement purpose. This saving tendency will be shown in the following discussions. The estimate of risk aversion rate may connect with the uncertainties in labor income and financial assets, which is in the reasonable range of most studies of portfolio choices (for instance, Campbell and Viceira (1999, 2006)).

The estimates of the labor income process are displayed in the bottom panel of Table 1-2. The coefficients are estimated from Equation 1-12 and 1-13 in the Section 2.1. The unemployment rate at age 25, $pu_{25} = \frac{e^{(\lambda_0+\lambda_1 25)}}{1+e^{(\lambda_0+\lambda_1 25)}}$, is about 4.43%, and slightly decreases across the life time ($\lambda_1 < 0$), until reaching $p_{64} = 4.30\%$ at the last period of working. While the estimated unemployment rate is at a reasonable level, the estimated labor income shock, σ_u, is relative high at 0.455. One possible interpretation for a higher σ_u is that some factors with important impact on labor income may not be captured by Equation 1-12, such as schooling and experiences of the workers.[33] Figure 1-5 shows how the predicted income process matches the data. The actual life cycle income-wealth ratio is obtained from SCF by log-averaging across households. As explained in Section 3, the life-cycle profile are corrected by eliminating cohort and time effects. It is worth noting that the estimated income-wealth profile fit the data well. The income-wealth profile implies a life-cycle trend of wealth accumulation. At the beginning of working life, most workers start with a lower wage, and the households do not have sufficient savings out of consumption, so the annual income is usually greater than accumulated wealth, thus the ratio of income to wealth is greater than one. This ratio can be as large as 15 during the twenties, but will dramatically decrease with age, and reach two or three around age 35. As the working experience accumulates, the earnings will increase, and so will the balance in the savings account. Therefore, the income-

[33] A complete formulation of labor income process may require the inclusion of time, schooling and experience (such as Belzil and Hansen (2002)). However, adding more variables into the labor income equation may request more state variables in the model, which in turn causes huge computational burden. Therefore, I choose the simplified version of labor income equation.

wealth ratio decreases with age gradually after age 35, and the income becomes lower than wealth after age 45. After mid of fifties, the earnings may start to decline, and the income-wealth ratio continue decreasing to around 0.2.

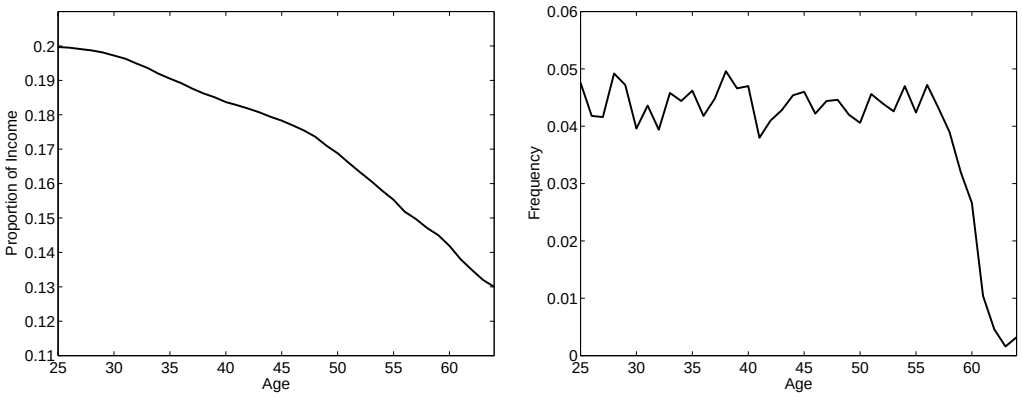
Figure 1-5: Log Income-Wealth Ratio over the Life-Cycle



With the estimates in hand, one can address how well the structural model fits the life-cycle portfolio choices. Figure 1-4 plots the simulated and actual asset allocation and location decisions over the life time, among which the two figures on the left display the equity ownership probability and average conditional equity shares in the conventional taxable account, and the two figures on the right show the equity holding distribution in the tax-deferred pension account. The model with pension account characteristics does break the "tax-efficient" portfolio rules, and produce life-cycle paths that mimic the observed household investment behavior. With the fitted model, the probability that households participate in the stock market in the taxable account is increasing in age, from around 25% at age 25 to about 60% before retirement, and the conditional shares of equity in that account have a mean around 50% over the life time, while in the tax-deferred account, the equity ownership rate remains at a very high level through out the whole working life, and conditional mean of equity shares is slightly decreasing in age from 70% to 40%. The estimated results suggest that there are a large amount of households only hold equities in the pension account, with all their taxable wealth invested in safe assets, and, during a certain period of life (from age 25 to 40), the equity shares in the pension account are higher than that in the taxable account. Therefore, the model successfully explain the observed evidence of asset allocation and location problem: households tend to hold stocks in both taxable and tax-deferred account, and they usually maintain a higher equity investment level in the pension account.

While the predicted distribution of asset allocation replicate the actual data closely in the taxable account, however, the model overpredicts the equity ownership in the tax-deferred pension account, and a relative lower equity share level during the old ages. These differences may reflect a weakness of the data, rather than the model. In some waves of SCF used in this study, the reported asset allocation in the pension account are in the type of categories. The questions in the survey have three choices: no stock at all, half in stocks and all in stocks. This design may have such consequence that part of the observations who have little equity investment report no stock at all. This tendency produce a lower observed equity participation rate, but a relative high equity conditional share. Apart from these features, however, the tight structure imposed by the model produces good predictions in terms of portfolio dynamics.

Figure 1-6: Retirement Savings over the Life-Cycle



(a) Retirement Saving Rate (b) Early Withdrawal Probability

I now turn to the question of how household save for retirement over the life cycle. Figure 1-6 describes the household saving behavior in the tax-deferred pension account. The Figure 1-6(a) on the left shows the contribution rate (retirement savings as a percentage of income) into the tax-deferred account conditional on that the retirement saving is positive, and the Figure 1-6(b) plots the probability of pre-retirement withdrawal from the pension account, which is subject to the pre-withdrawal penalty 10%. From Figure 1-6(a), we can see that the average contribution rate into the tax-deferred account is slightly decreasing in age, but remains at a relative high level in most life time. This trend suggests that most households start saving for retirement at very young age, and they put a lot of savings in the retirement account. The high saving rate in the pension account reflects two things: (1) the tax benefits and other pension account advantages

(such as employer matches) and (2) the relative high average return earned on the assets (more equity investment) held in the retirement account. Moreover, because of the labor income shocks, households on average never reach the saving limit (20%) in the tax-deferred account, and they also pre-withdraw some funds occasionally for regular consumptions (see Figure 1-6(b)). The positive pre-retirement withdrawal rate may be a result of the high level of retirement savings. As the household approaches retirement, the pre-retirement withdrawal rate dramatically decreases to almost zero, reflecting the high propensity of retirement savings during these ages.

Figure 1-7: Retirement Wealth over the Life-Cycle

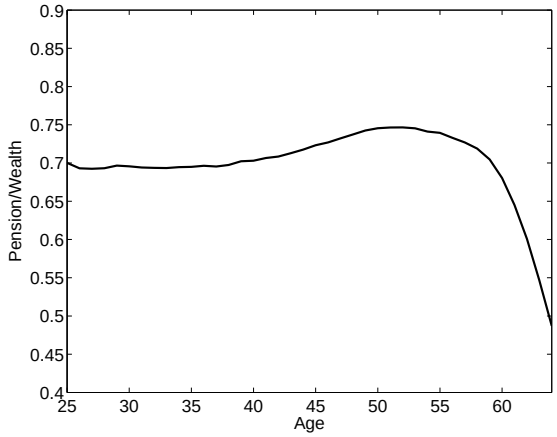


Figure 1-7 displays the predicted pension-wealth ratio over the life cycle. The average fraction of total wealth held in the pension account remains at a high level during young ages, and reaches its maximum of 75% at age 50, well before the head of the household reaches retirement age. The decline in the fraction of total wealth held in the retirement account in the years prior to retirement may result from the lower fraction of total savings allocated to the retirement account at these ages. It has to be noted that almost all households in the simulation have positive retirement wealth over the life time, but there are about 30% of the households in the data do not have any savings in the pension account. This difference between simulated and observed profiles might be explained by the assumption in the theoretical model: all households face the same type of pension account characteristics. The estimated employer matching rate and transaction costs benefit in the tax-deferred pension account make it a very popular choice for most households, thus making the retirement saving rate and accumulated retirement wealth at a relative high level. Holding other constant, if the employer does not provide any matching benefit, the savings in the retirement account will decrease to

zero during the young ages and increase gradually with age. Moreover, there are about 90% of the households having no pension wealth between age 25 to 35, and 30% of them no pension wealth between 35 to 45. How will the households react when the pension account policies change is explained in the next several sections.[34]

1.5.2 The Role of Employer Matching Policy over the Life-Cycle

In the Defined Contribution pension plans, employer matching policy is one of the most important designs. Almost in all employer sponsored DC pensions (such as 401(k) and 403(b)), employers match some or all of employees' contributions. This phenomenon raises the question of what is the role that employer matching strategy plays in the household behavior. This section explains the impact of employer matching policies on household retirement saving decisions and portfolio choices.

Table 1-3: The Estimated Elasticity with respect to Matching Rate

	Taxable Account		Tax-Deferred Account		Retirement Savings
Age	Equity Ownership	Equity Share	Equity Ownership	Equity Share	Pension Wealth
25-29	-31.1535	-9.8060	3.8401	5.4377	0.2949
30-34	-18.7860	-12.0746	4.0875	5.1420	0.3633
35-39	-8.4524	-9.3201	2.7063	2.9442	0.3327
40-44	-2.9888	-3.0939	1.2829	1.2545	0.2863
45-49	-0.9422	-1.0152	0.3230	0.3964	0.2438
50-54	-0.3127	0.1588	0.0410	0.2354	0.2354
55-59	-0.8528	-0.0457	-0.0322	0.1972	0.2311
60-64	0.8109	0.3559	0.0051	-0.5683	0.2369
Total	-7.8347	-4.3551	1.5317	1.8799	0.2784

Given the estimates in hand, Table 1-3 shows the elasticities of portfolios and savings with respect to the change in employer matching rate. The numbers in the table are five-year average from age 25 to 64, with the total average on the bottom. The columns display the matching rate elasticity of equity investment in the taxable account and tax-deferred pension account, as well as the elasticity of retirement saving decisions over the life time. Consistent with the findings in Engelhardt (2004), the proportion of wealth in the pension account respond positively to the changes in matching rate,. Although inelastic, the life-cycle trend of the elasticity in pension wealth ratio suggests that younger

[34] A more complete analysis may involve different type of retirement plans, and households make decisions based on different account characteristics. Due to the consideration of the computational burden, I choose to set up the model with the simplified version.

households are more responsive to changes in employer matching policy. The portfolio choices are quite sensitive with respect to the changes in matching rate. During the ages 25 to 50, equity holdings in both types of saving accounts respond elastically to matching policy changes, with positive response in the tax-deferred account and negative in the taxable account. This finding is a optimal response to changes in the saving behavior. As a higher fraction of wealth held in the pension account, households tend to boost equity holdings in the retirement saving account for the higher returns and reduce those investments in the taxable account for precautionary saving purpose. Moreover, the life-cycle trend of the elasticity indicates that the impact of employer matching policy on portfolio choices is more apparent during the young ages. Households in ages $25-29$ have a matching rate elasticity of equity ownership in the taxable account at -31.15 and in the tax-deferred account at 3.84, but this elasticity is only about 0.81 in the taxable account during ages $60-64$ and 0.0051 in the pension account. One possible explanation of this phenomenon is that the purpose of young households saving in pension account is to enjoy higher asset returns from tax benefit and pension favored features, so their portfolios are more likely to get affected by policy changes, while older households who are more concerned with the accumulation of retirement wealth are less likely to get influenced.

To make the point clearer, Figure 1-8, 1-9 and 1-10 provide a graphical illustration of the impacts of employer matching strategies on household behavior. The four graphs in Figure 1-8 show the changes in life-cycle portfolio choices. There are two implications that can be derived. Firstly, the figure displays the change in household behavior when the matching rate decreases by 10% from 0.6768 to 0.5768. Consistent with the results in Table 1-3, the lower the matching rate implies a lower proportion of total wealth held in the pension account, thus it decreases both the equity ownership and conditional equity holdings in that account, with a larger effect on young households (e.g. at 30s, about 60% decrease in equity ownership and 50% decrease in equity shares) and smaller effect on older ones (e.g., at 50s, the equity ownership decreases about 5% and equity shares about 3%). In order to balance the riskiness in investment, households thus hold more equities in the taxable account. From age 25 to 45, the average change is about 52% increase in equity ownership and 45% increase in average equity shares, while the change during ages above 45 is relative small, around 2% increase in equity

ownership and 0.5% increase in equity shares. The results further suggest that a change in the employer matching rate will significantly influence the young households' asset allocation and location decisions. Secondly, the figure also shows the change of household saving and investment behavior after a decrease of matching rate from 0.5768 to 0.4768. Although this 10% decrease still has the same effects on portfolio choices as the previous change, the magnitude of its influence is apparently smaller, which tells us that the impacts of employer matching strategies are not uniform across different levels. Any policy change or regulation should consider both the size of change and marginal effects.[35]

Figure 1-9 displays the change in overall equity holdings after the decrease in employer matching rate. Given that almost all households participate in the equity market, the conditional overall fitted equity proportion decreases in age. When employer matching rate decreases, the income the households can get implicitly decreases too, thus their equity investment becomes conservative, especially for the young households. The average equity proportion decreases about 10% during ages 25 to 35, as a response to a matching rate decrease from 0.6768 to 0.5768. The result suggests that a proper increase in the employer matching rate will encourage young households to hold more equities in the financial market. Figure 1-10 is about the change in pension-wealth ratio after a decrease in employer matching rate. The decrease in pension-wealth ratio comes from the deduction in the employer contribution and the decrease in the households' own savings. The relative larger decrease during the younger ages reflects a larger change in the retirement saving behavior during those ages.

1.5.3 The Role of Employer Stock Matches

In addition to the form of cash, some employer matches also take the form of company stock (mainly in 401(k) types). Meulbroek (2002), Ramaswamy (2003) and Poterba (2003) suggest that holding company stock is risky because it raises the volatility of the retirement wealth. Some other researchers (such as Campbell and Viceira (1999), Davis

[35]Since different level of employer matching rates display different effects on household behavior, I have done an additional analysis on the household responses to an employer matching rate change from zero to 0.1. The results indicate that household retirement saving behavior (pension saving rate and accumulated pension wealth) reacts to this change significantly, especially during the young ages, but the investment behavior does not display significant difference. This finding suggest different employer matching policies have different roles in explaining the household behavior.

Figure 1-8: The Role of Employer Matching Policy in Portfolio Choices

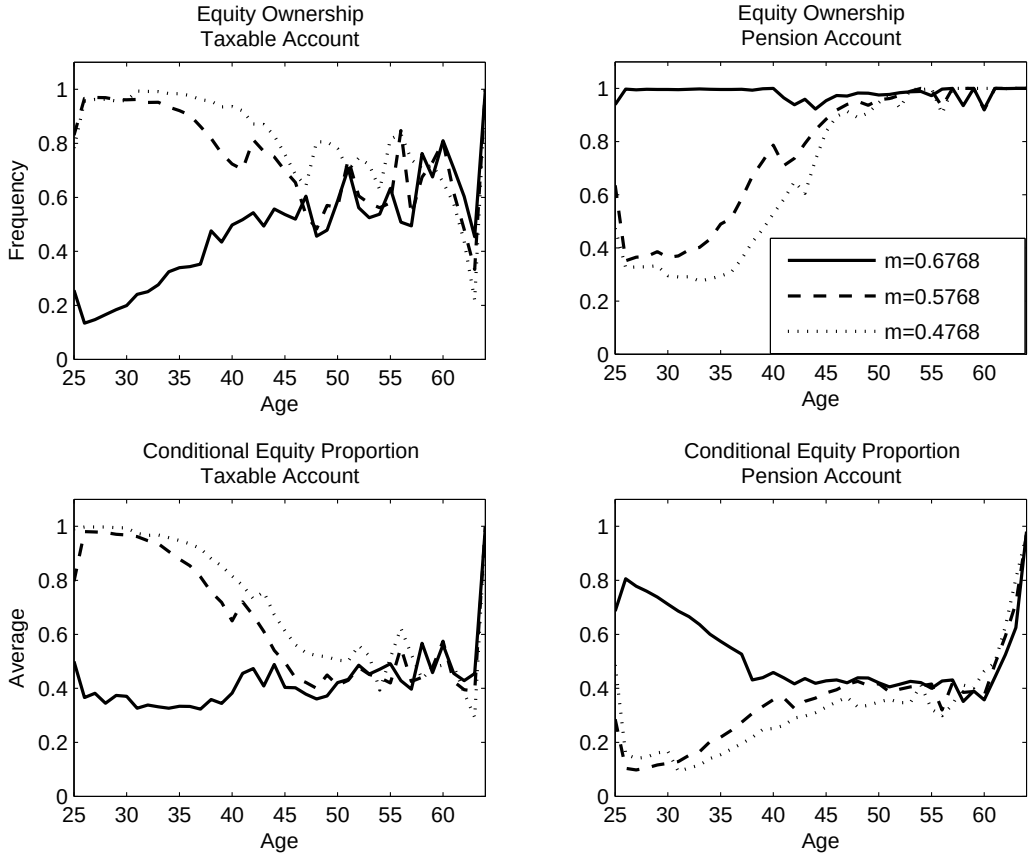


Figure 1-9: The Role of Employer Matching Policy in Overall Equity Holdings

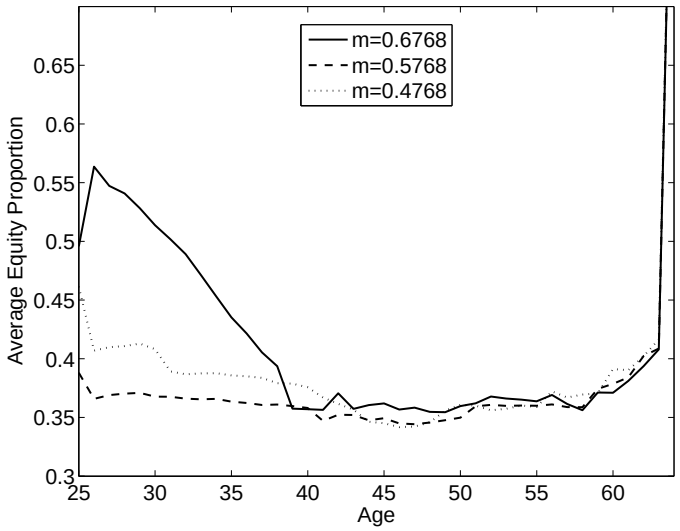
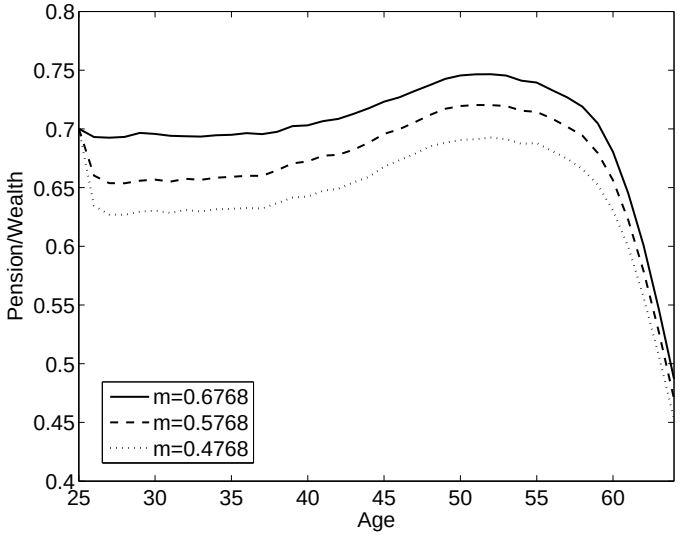


Figure 1-10: The Role of Employer Matching Policy in Retirement Savings

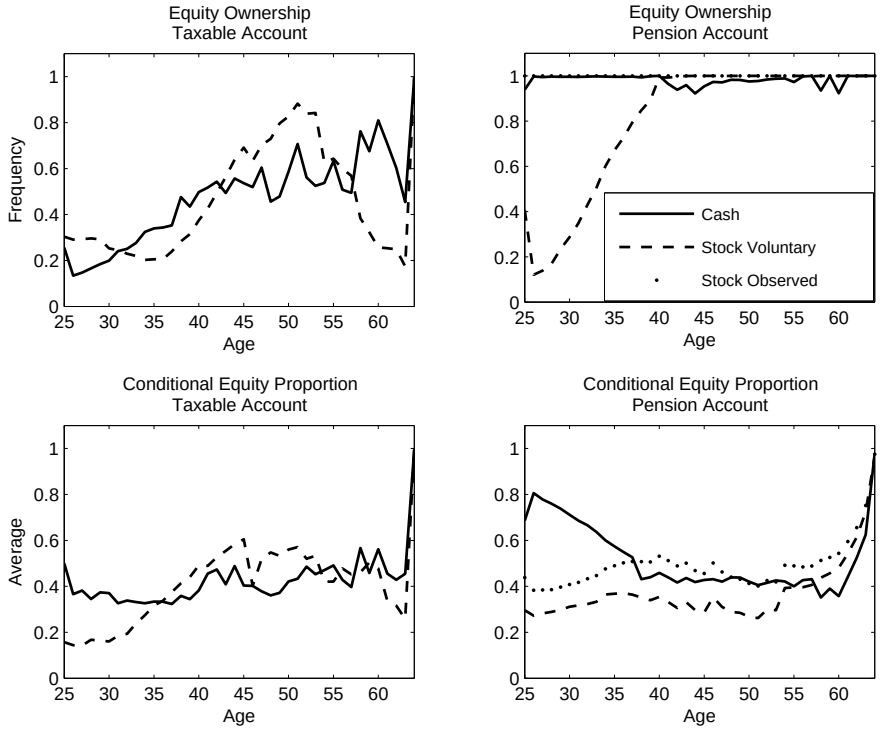


and Willen (2000a,b), and Heaton and Lucas (2000)) also point out that company stock is considered to be a more risky investment because it is likely positively correlated with labor income risk. Therefore, a worker with company stock investment in his pension accounts may face the risk of losing his job and his retirement wealth at the same time. Then the question would be, if putting inside a life-cycle model, how will company stock matches change households' investment decisions. In the following paragraphs, I study the consequences two scenarios: (1) changing the employer cash match to stocks, remaining at the estimated rate 0.6768; (2) under the condition of stock matches, adding the correlation between the equity return risk and the labor income shock into the model, and fixing the correlation at $corr(r,u) = 0.1$.

In the first scenario, after changing the employer cash matches to stock, the retirement saving rate and pension-wealth ratio do not deviate from the original predicted level, which suggests that the household actively change the portfolio combination in order to keep the optimal value of retirement wealth. Figure 1-11 compare the portfolio choices under the condition of the employer cash match with the stock match. There are two lines in the graphs of pension account representing the result of employer stock matches, one showing the household voluntary portfolio choice (the dash line), and the other observed equity distribution (the dot line), which is the summation of household voluntary equity investment and mandatory employer stock match. Because of the riskiness of stocks, employer stock matches tend to reduce the voluntary equity investment of the employees in the retirement account, resulting in decreases in both the equity

ownership (about 4% on average) and conditional equity shares (about 3% on average). The effect is more significant for young households, who are more sensitive to pension account policies (a decrease of equity ownership up to 20% at age 20s). But the observed equity ownership in the pension account is very high, almost 100% for all ages. The portfolio choices in the taxable account under employer stock match does not differ much from those under employer cash match, with a slightly higher equity ownership and a slightly higher average equity proportion.

Figure 1-11: Portfolio Choices over the Life-Cycle: The Role of Employer Stock Matching



In the second scenario, households face a employer stock match, and the equity risky return is positively correlated with the labor income shock, namely a higher equity return more likely accompanied by a higher level of income. Figure 1-12 illustrates the differences in household behavior between two cases, one of which is that the shocks in equity returns and labor income are not correlated, and the other is that the shocks are correlated at a rate of 0.1. The positive correlation of risks exhibits different effects on household behavior for different life stages. During the younger ages (from age 25 to 45), the correlated risks indicate a higher risk in the equity investment. From the consideration of precautionary savings, people tend to save less for retirement purpose, remain a larger proportion of total wealth in the taxable account, and invest less equi-

ties in the taxable account. But the households would voluntarily hold a larger share of equities in the pension account to enjoy the higher returns. Therefore, during this period of time, an employer company stock match which is positively correlated with labor income may result in even higher concentrated equity investment in the pension account (nearly 100% equity holdings). This finding is consistent with the empirical results discussed in Benartzi (2001) and Liang and Weisbenner (2002a), who show that employer company stock matches cause participants to hold more company stocks in the pension account. During the older ages (from age 45 to retirement), however, in response to the retirement saving consideration, the investment behavior in the pension account becomes conservative, together with a higher equity holdings in the taxable account. Because of the bigger risk from the positive correlation, such investment strategy ends up with a even higher fraction of pension-wealth ratio during the old ages, and a higher rate of pre-retirement withdrawal from retirement wealth.

1.5.4 The Consequences of Change in Social Security

Social Security is an important income source for most retirees. However, it is forecast to face financial difficulties in the coming decades. Some researchers and investment advisors suggest privatizing some part of the current Social Security system, but few studies have quantitatively shown the possible effects of such change on equity investment and retirement wealth. In this section, I study a policy change by transforming the Social Security taxes and retirement payments into a tax-deferred retirement saving account during working life, and analyze the consequences of this change.

Before talking about the results, I have to point out the changes caused by removing Social Security taxes and payments. First, this modification makes the tax-deferred pension account the only income source during retirement. Households may also get resource from their regular savings in the taxable account, but they do not have additional income from any Defined Benefit type pensions. Second, the popularity of the retirement saving account is reduced due to the deduction in the tax rate (Social Security tax). Since the savings in the pension account is on a pretax basis, the higher the tax rate, the more attractive the retirement savings would be.

Figure 1-13 shows the consequences after removing Social Security payments, $h = 0$, and reducing total tax rate, τ, by 6%, which is around the current taxes col-

Figure 1-12: Portfolio Choices an Retirement Savings over the Life-Cycle: Correlation in uncertainties

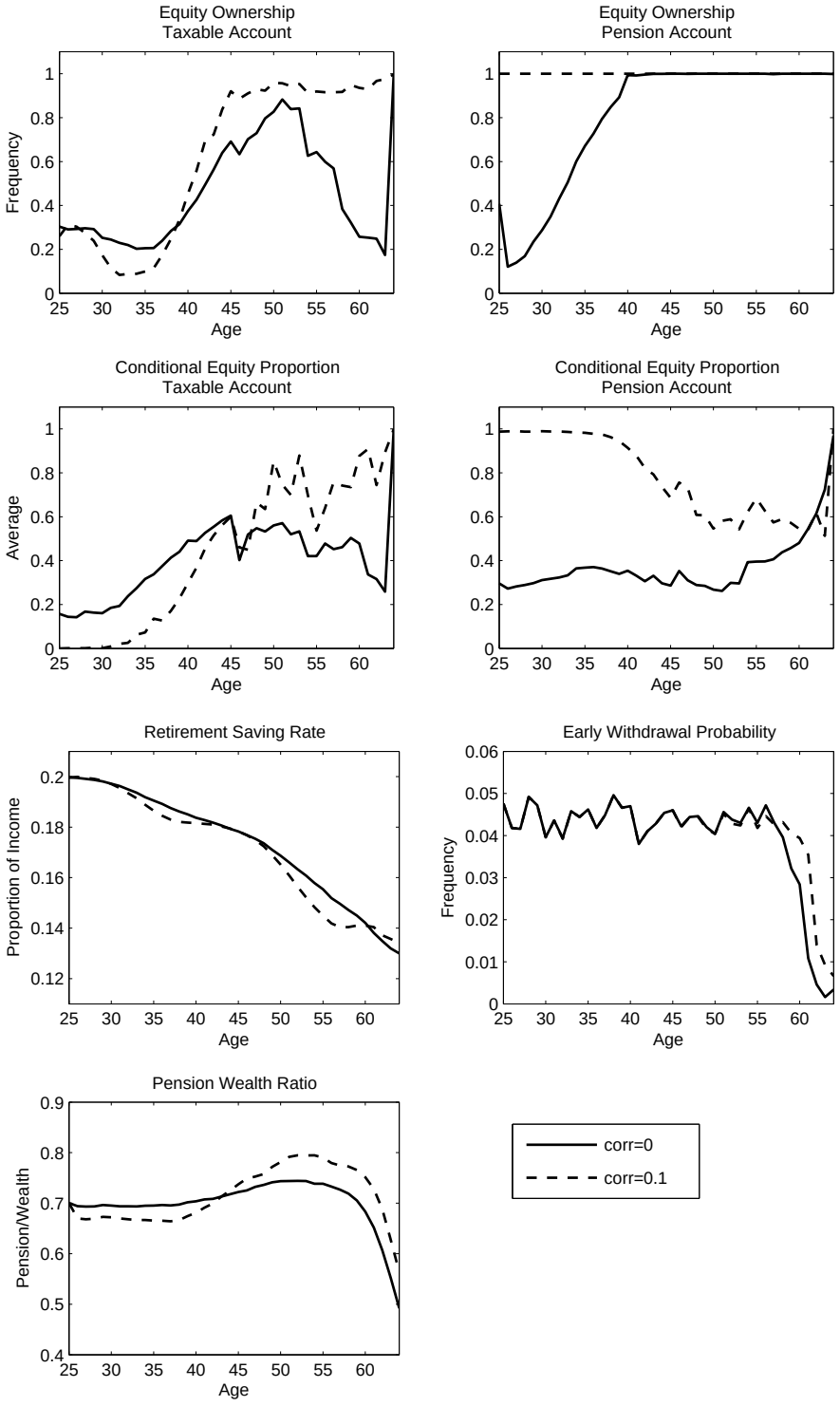


Figure 1-13: Portfolio Choices and Retirement Savings over the Life-Cycle: Change in Social Security

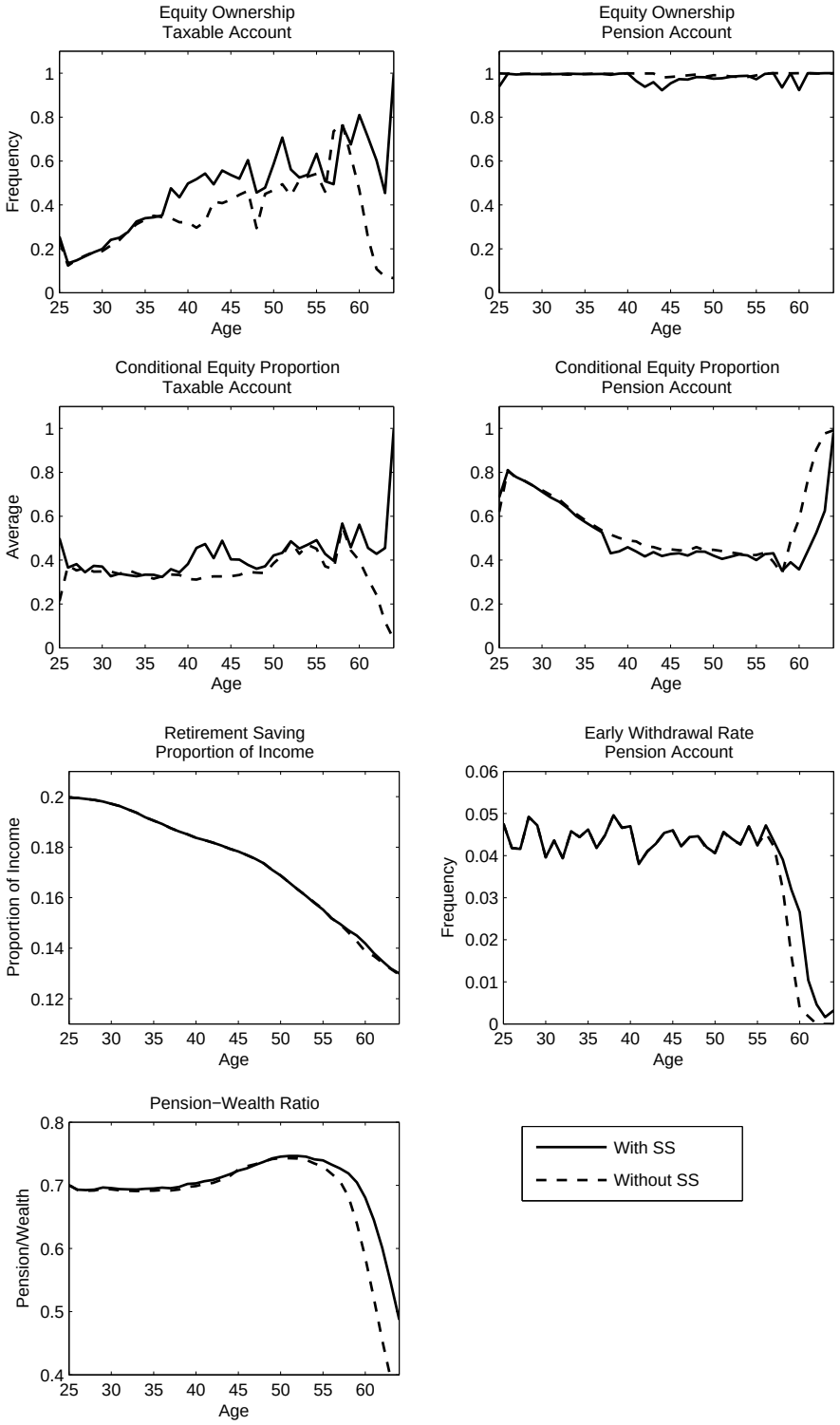


Figure 1-14: Portfolio Choices and Retirement Savings over the Life-Cycle: Changes in Saving Limit

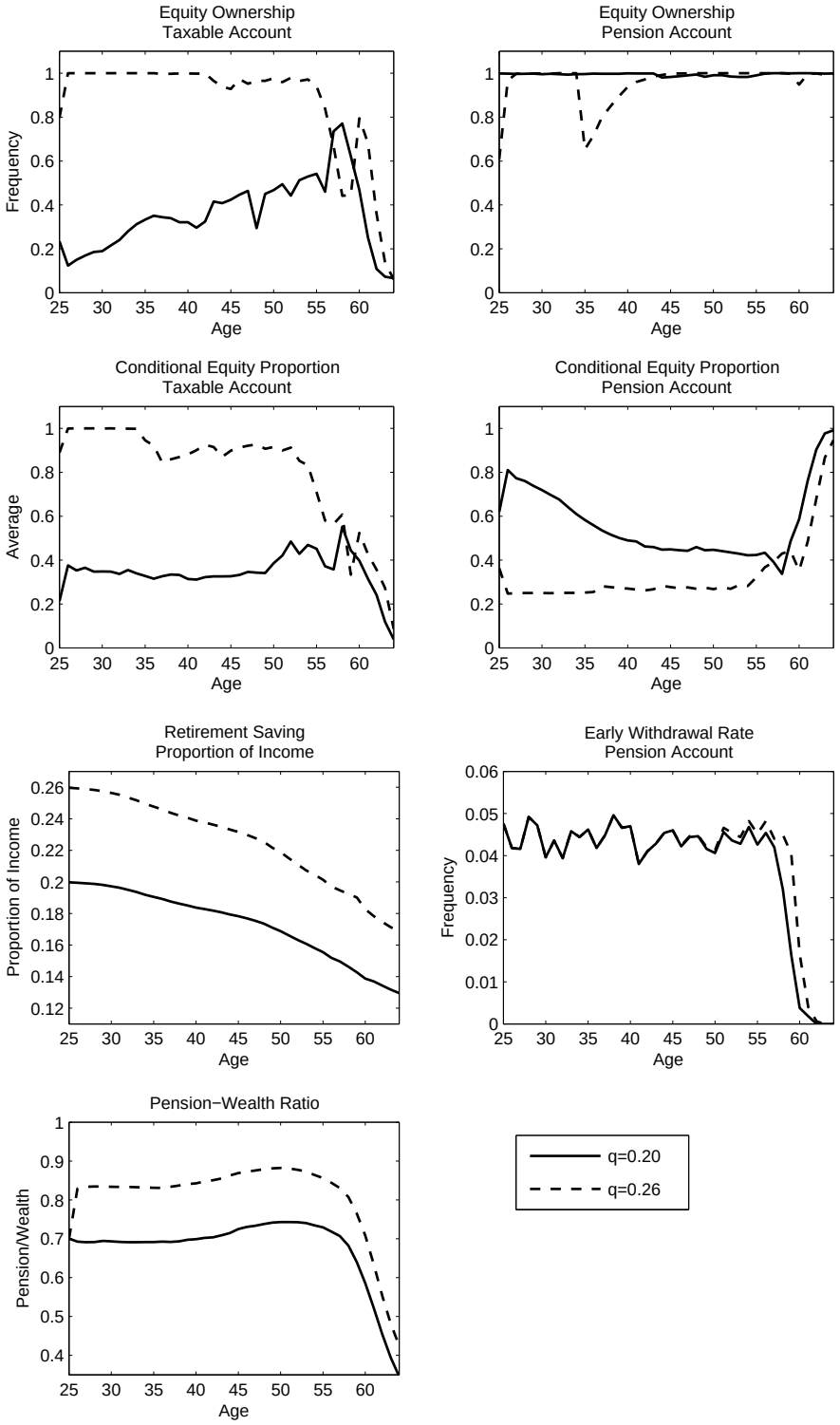
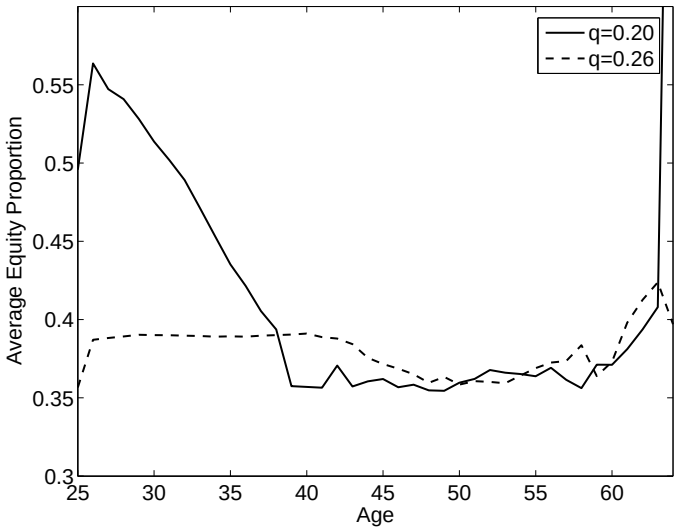


Figure 1-15: Overall Equity Proportion: Changes in Saving limit



lected for Social Security purpose. It is suggested by the figure that the effect of this change kick into household behavior only right before retirement, and both portfolio choices and retirement saving decisions remain unchanged before age 55. There are two implications that can be derived from the household behavior between age 55 to 64. First, as the retirement account becomes the only income source for retirement, households may value it more than before, so they hold more equities in that account for higher returns. The equity ownership in the pension account increases by 1% during age 55 to 64, and equity proportion in that account increases by 13% on average. In addition, in order to keep sufficient balance in the pension account, people reduce the early withdrawal rate by 0.6%, and they invest more in safer assets in the taxable account to fund consumption needs (an average decrease of 20% in both equity ownership and conditional proportion). Second, since the tax rate on earnings is reduced by 6%, and the retirement saving limit remains at the same level, more savings are held in the taxable account, and consequently the fraction of total wealth held in the pension account becomes lower.

Some people may argue that if there is no Social Security benefit, then households may want to save more for the retirement purpose. Therefore, I study an additional case by increasing the saving limit in the pension account to 26% of the earnings, which is 6 percent more than before, and the results are shown in Figure 1-14.[36] The households

[36]One thing need to note about the case of changing saving limit. In this analysis, I implicitly assume that the employer matches every dollar the employee saves in the pension account, up to the saving limit. This is a reasonable assumption given that every dollar tax contribution into the Social Security system

reaction to this change is quite large. They actively save more in the pension account to meat the new limit, which leave less savings in the taxable account, and thus result in a higher pension-wealth ratio through out the life time. In regard with portfolio choices, except for the ages right before retirement, most households maintain a "tax-efficient" asset allocation and location strategy, in which they hold high-taxed asset (i.e. bonds in the U.S. case) in the tax-deferred account, but low-taxed asset (equity) in the taxable account. Because of the relative low capacity of taxable account in this situation, the equity holdings spill over to the tax-deferred account. This phenomenon might reflect the fact that when the wealth in the pension account is relative high, the effect of tax benefit is larger than the role of employer matching policy and transaction costs difference, so household would like to hold high-taxed asset in the tax-deferred account. There are about 25% more of pension wealth are held in bonds. An alternative explanation of the lower equity investment in the pension account might be that since the pension account becomes the only retirement income, households tend to invest conservatively and hold more safe assets. However, during the periods approaching retirement, the behavior of the households is similar to the case with lower saving limit. Considering the overall equity proportion, this change does not induce more shares of total wealth held in equities (see Figure 1-15). Since more wealth are held in the pension account, but less proportion of equities are invested in that account, the overall equity proportion decreases about 10% during the ages 25 to 35.

1.6 Conclusion

This study contributes to the analysis and understanding of household saving decisions and portfolio choices in the taxable and tax-deferred pension accounts, as well as the effects of the tax-deferred pension account designs. I develop a new approach by incorporating the pension account characteristics into a dynamic asset allocation and location problem. I model households' behavior conditional on employer matching strategies and other features in the tax-deferred account, and estimate structural parameters and household portfolio choices using the Method of Simulated Moments. The model fits the data well and provides a framework for explaining the role of employer matching

by the employee is accompanied by the tax contribution from the employer too. The Social Security tax is collected by the method of $50/50$ between employees and employers.

policies in household optimal saving and portfolio decisions. This study can further entail the question of what would be the consequences of transforming the current Social Security system to an individual retirement account.

The results of my paper indicate that the higher equity concentration in the pension account is an optimal response to the pension account designs. In particular, the employer matches in the pension account cause a higher proportion of savings allocated into the pension account. Therefore, the relative less assets in the taxable account make the households invest more safe assets in that account for the precautionary purpose, and they are more likely to hold equities in the pension account to maintain an optimal portfolio mix. This asset allocation strategy ends up with a lower equity holding in the taxable account, but a relative high equity investment in the tax-deferred account. From the perspective of life cycle, younger households who save in the retirement account for pension-favored benefits are more likely to be affected by the change in matching rates, while older households who have higher propensity for retirement savings are less likely to be influenced. My results also show that the employer stock match makes the investment in the pension accounts riskier than a cash match, so the households with a stock match from the employer tend to voluntarily reduce their own equity holdings in the tax-deferred account. With the estimated model, I further find that households actively respond to the transformation of Social Security taxes and payments to a tax-deferred retirement saving account. Since the pension account becomes the only income source for retirement, households tend to save more for the retirement purpose and hold more safe assets (bonds) in that account.

There are two interesting avenues for future research. First, the method in this article could be extended to study richer household intertemporal choices with taxable and tax-deferred accounts, such as labor supply and retirement investment decisions, and the model could also be used to study the behavior of people with different occupation and education levels. With proper modification of the existing model, I think the effect of tax volatility and social insurance program can also be further analyzed. Second, employer matching policy is one complicated part of pension account designs. It comes with different formats, for instance, first dollar match, unconditional matches, contribution-based match, and matching caps. I expect that, with a complete data set about pension plan descriptions, this model could be extended to analyze the different

marginal effects of detailed employer matching policies.

1.7 Appendix

A.1 Household Problem During Retirement

This part will describe the maximization problem during retirement. Each household retires in period $K = 65$, and live until the last period of life $T = 85$. I assume that the household liquidates the pension account at the beginning of retirement, and also receives an endowment H_K, which is the expected value of Social Security payment in the rest years of life. Then the total wealth of each household at period $t = K$ is

$$W_K = W_K^A + (1-\tau)W_K^P + H_K.$$

From period $t = K$ to $t = T$, Households make consumption decisions, and the wealth will accumulate at a fixed rate of return $\bar{r}$. In practise, I define $\bar{r} = \frac{1}{2}(1-\tau_b)r^b + \frac{1}{2}r^\tau$, which the after-tax return of a portfolio with half invested in stocks and half in bonds. The household's problem after retirement can be written as,

$$max_{C_{t=K}^T} E\left(\sum_{t=K}^{T} \beta^t [F(t)U(C_t) + (F(t-1) - F(t))B(W_t)]\right), \tag{A-1}$$

s.t.

$$W_{t+1} = (W_t - C_t)\cdot \bar{r}, \tag{A-2}$$

$$C_t \geq 0, W_t \geq 0. \tag{A-3}$$

Defining the value function for the household problem at time t as V_t, the Bellman equation for this maximization problem can be written as,

$$V_t(W_t) = max_{C_t}\left[e^{-\vartheta_t}U(C_t) + (1-e^{-\vartheta_t})B(W_t) + e^{-\vartheta_t}\beta E_t[V_{t+1}(W_{t+1})]\right] \tag{A-4}$$

subjective to equation (A-2) and (A-3).

The setup of the household problem during retirement makes the model homogeneous of degree $(1-\gamma)$ in the total wealth. After normalizing the problem by total wealth, the problem becomes,

$$v_t = max_{c_t}\left[e^{-\vartheta_t}U(c_t) + (1-e^{-\vartheta_t})\frac{bq}{1-\gamma} + e^{-\vartheta_t}\beta E_t[v_{t+1}\delta_{t+1}^{1-\gamma}]\right] \tag{A-5}$$

s.t.

$$\delta_{t+1} = (1-c_t)\cdot \bar{r}, \tag{A-6}$$

where $v_t = V_t(W_t)/W_t^{1-\gamma}$ is the normalized value function, $c_t = C_t/W_t$ is the consumption-wealth ratio, and $\delta_{t+1} = W_{t+1}/W_t$ one plus the growth rate in wealth from period t to period $t+1$.

The above problem has one state variable t, and one control variable c_t,consumption-wealth ratio, and can be solved using backward recursion. At the terminal date T, the household value function takes the know value,

$$v_T = \frac{bq}{1-\gamma}$$

The value function at date T is then used to solve for the optimal decision rules at date $T-1$. The procedure is repeated recursively for each time period until the solution for date $t = K$. The value function at the beginning of retirement, v_K, will be used to find solutions for the problem during working time.

A.2 Normalization of the Household Problem

I simplify the optimization problem by normalizing by the household total wealth W_t. Let $p_t = W_t^P(1-\tau)/W_t$ be the fraction of the investor's total wealth that is held in the retirement account, $s_t = s_t^P/W_t$ be the ratio of contribution to pension account to the total wealth, $c_t = C_t/W_t$ be consumption-wealth ratio, and let $y_t = Y_t/W_t$ be the income-wealth ratio as previously defined. Then equation (1-1) can be written

as following dynamic equation:

$$W_{t+1} = [(1-p_t-c_t+y_t\cdot(1-\tau)-s_t(1-\tau-pnl\times I)\cdot(1-tr\times I(\alpha_t>0))R_t+(p_t+(1-\tau)s_t)R_t^P(m)]W_t \tag{A-7}$$

The linearity of the dynamic wealth equation and the assumption of CRRA preferences ensure that the model has the property that the consumption, saving and portfolio decision rules, $c_t, s_t, \alpha_t, \alpha_t^P$, are independent of total wealth, W_t. Furthermore, with the above normalization, the relevant state variables for the investor's problem become (p_t, y_t). Defining $v(p_t, y_t) = V(W_t^A, W_t^P, Y_t)/[W_t^{1-\gamma}]$ to be the normalized value function and $\delta_{t+1} = W_{t+1}/W_t$ to be one plus the growth rate in wealth from period t to period $t+1$, the household's problem in working life can restated as follows:

$$\begin{aligned} v(p_t,y_t) = max_{(c_t,s_t,\alpha_t,\alpha_t^P)} &\left(e^{-\vartheta_t}U(c_t)+(1-e^{-\vartheta_t})\frac{bq}{1-\gamma}+e^{-\vartheta_t}\beta E[v(p_{t+1},y_{t+1})\delta_{t+1}^{1-\gamma}]\right) \\ t &= 1,\ldots,K-1, \end{aligned} \tag{A-8}$$

s.t.

$$\begin{aligned} \delta_{t+1} =&(1-p_t-c_t+y_t\cdot(1-\tau-\tau^{ss})-s_t(1-\tau-pnl\times I))\cdot(1-tr\times I(\alpha_t>0))R_t \\ &+(p_t+(1-\tau)s_t)R_t^P(m) \end{aligned}$$

$$p_{t+1} = \frac{(p_t+(1-\tau)s_t)R_t^P(m)}{\delta_{t+1}}$$

$$y_{t+1} = e^{f(t+1)}\cdot u_{t+1} = e^{l_0+l_1(t+1)+l_2(t+1)^2}\cdot u_{t+1}$$

$$s_t \le q\cdot y_t$$

$$c_t \ge 0, p_t \ge 0, 0 \le \alpha_t^P, \alpha_t \le 1.$$

The value function of the first retirement period can be defined as,

$$v(p_K, y_K) \equiv v_k = V(W_K)/[W_K^{1-\gamma}]$$

and

$$\begin{aligned} \delta_K =&(1-p_{K-1}-c_{K-1}-(1-\tau-\tau^{ss})\cdot y_{K-1}-s_{K-1}(1-\tau-pnl\times I))\cdot(1-tr\times I(\alpha_{K-1}>0))R_{K-1} \\ &+(p_{K-1}+(1-\tau)s_{K-1})R_{K-1}^P(m)+(1-\beta^{T-K-1})/(1-\beta)\cdot h\cdot\bar{y}_{K-1} \end{aligned}$$

where h is the replacement rate of Social Security payment defined in Section 2.

A.3 Numerical Algorithm

The problem during retirement can be derived analytically, while that during working years need to be solved numerically, so the rest of this section is a discussion of solutions during working life. Standing at each working date, one can rewrite the Bellman equation (A-8) as,

$$\begin{aligned} v(p_t,y_t) =& max_{(c_t,s_t,\alpha_t,\alpha_t^P)}\{e^{-\vartheta_t}U(c_t)+(1-e^{-\vartheta_t})\frac{bq}{1-\gamma} \\ &+e^{-\vartheta_t}\beta(1-pu_t)\int\int v(p_{t+1},y_{t+1})\delta_{t+1}^{1-\gamma}dF(r)dF(u) \\ &+e^{-\vartheta_t}\beta pu_t\int v(p_{t+1},0)\delta_{t+1}^{1-\gamma}dF(r)\}. \end{aligned} \tag{A-9}$$

The above equation indicates that each household face two types of uncertainties, one of which is the risky asset, and the other is labor income shock. A two-dimensional Gauss-Hermite quadrature is performed to evaluate the expectation in (A-9).

To solve for the optimal saving and investment decisions, I discretize the endogenous state variables, (p_t, y_t), into a grid of (20×21) over the following ranges: pension-wealth ratio $p_t \in [0,1]$, and income-wealth ratio $y_t \in [0,10]$. In order to capture the curvature of the policy rules at low values of income-wealth ratio, the grid will be finer for $y_t \in [0,2]$. At each point in the state space, in order

to find the optimal choices , I need to further discretize the choice space, $(s_t, \alpha_t, \alpha_t^P)$. The saving-wealth ratio, s_t is discretized into 20 grids over $[-1,2]$, where the upper bound is 20 percent of the maximum labor income (saving limit in the pension account), and the lower bound is the maximum pension-wealth ratio. The agent will withdraw some money out of the tax-deferred pension account when $s_t < 0$, have no activity when $s_t = 0$, and make some positive contributions otherwise. Both α_t and α_t^P are discretized into 5 grids over $[0,1]$, indicating the share of equities held in taxable account and tax-deferred account respectively. For each value in the state space, $(p_t, y_t)^j$, and each value in the consistent choice space, $(s_t, \alpha_t, \alpha_t^P)^{ij}$, I find consumption-wealth ratio, c_t^{ij}, that satisfies equation (A-9). Then the values in the choice space are compared to yield the optimal combination at the state point, $(c_t, s_t, \alpha_t, \alpha_t^P)^j = max_i[(c_t, s_t, \alpha_t, \alpha_t^P)^{ij} | (p_t, y_t)^j]$. A two-dimensional linear interpolation is used to calculate the value function for points in the state space that lie between the grid points, and extrapolation is applied when state values move out of the grid. Since extrapolation is much less precise than interpolation, I adopted a simple checking approach to assure that the state values in the simulations remains within the grid with probability 0.95.

In choosing the size and coarseness of the grid, I face the usual trade-off between precision and computing time. Adding points on the grid gives a finer approximation of the policy rules, but also increases the need to calculate equation (A-9). The current size of this problem takes more than half an hour on a 3.4GHz Intel Pentium IV Xeon CPUs.[37] After paralleling the program onto 80 processors using Message Passing Interface (MPI), the solution can be obtained in about 30 seconds. As the number of processors increases, the marginal time that can be saved may be compensated by the time spent in the message passing (see Swann (2000) for details). The number of processors in choice is around the point that marginal time gains equal to marginal time losses.

A.4 The Simulated Method of Moments

Suppose there are J moments in the estimation. Since each element of those moments is the expectation of one distribution, I define ζ^j is the variable for each distribution, $j = 1, \ldots, J$, and I_j the corresponding number of observations of that variable. The simulated expectation for variable j and parameter set θ is $\bar{\zeta}^j(\theta)$. Let $g(\theta) = [g_1(\theta), \ldots, g_J(\theta)]'$ be a vector in which $g_j(\theta) = \frac{1}{I_j}\sum_{i=1}^{I_j} \zeta_i^j - \bar{\zeta}^j(\theta)$, that is, the distance between the actual and predicted moments. The method of simulated moments minimizes the weighted average distance between the actual and predicted distributions $g(\theta)'Wg(\theta)$, in which W is a weighting matrix.

In the first stage, the identity weighting matrix is used to minimize,

$$g(\theta)'Ig(\theta),$$

with respect to θ. Using the computed $\hat{\zeta}$, an estimate variance-covariance matrix $\hat{\Omega}$ can be constructed,

$$\hat{\Omega} = E[(\zeta_i - \bar{\zeta}(\hat{\theta}))(\zeta_i - \bar{\zeta}(\hat{\theta}))']$$

with $\hat{\Omega}_j = \frac{1}{I_j}\sum_{i=1}^{I_j}(\zeta_i^j - \hat{\zeta}^j(\hat{\theta}))^2$ on the diagonal, and zeros off-diagonal.

$W = \hat{\Omega}^{-1}$ is the optimal weighting matrix, so in the second stage

$$S(\theta) = g(\theta)'\hat{\Omega}^{-1}g(\theta),$$

is minimized. The distribution of the resulting estimate $\tilde{\theta}$ is

$$\sqrt{I}(\tilde{\theta} - \theta_0) \underrightarrow{d} N(0, Q),$$

where I is the number of observations, and letting ς be the ratio of the number of observations to the number of simulated points,

$$Q = (1+\varsigma)(G_\theta'\hat{\Omega}^{-1}G_\theta)^{-1}$$

where $G_\theta = E[\partial g(\tilde{\theta})/\partial\theta']$.

[37] The program is finished at Seawulf Cluster. Seawulf Cluster is a computational resource at Stony Brook University, equipped with 3.4GHz Intel Pentium IV Xeon CPUs, 470 processors, and a couple of MPI systems. (http://www.stonybrook.edu/seawulfcluster/index.shtml)

To test the overidentifying restrictions, one can use

$$\chi^2_{J-14} = Ig(\tilde{\theta})'\hat{\Omega}^{-1}g(\tilde{\theta}),$$

which is distributed asymptotically as Chi-squared with $J-14$ degrees of freedom.

Chapter 2

Company Stock Investment in 401(k) Pensions

2.1 Introduction

401(k) plan is one type of employer-sponsored defined contribution plans that are sponsored by some profit organizations. Employees in 401(k) not only have access to a general index of stocks, but also can make investment in their own company stocks. This paper tries to analyze the factors that affect the individual decisions of company stock holdings in the 401(k)-type account.

In recent years, own company stock investments have grown rapidly in retirement accounts. At many large firms, particularly those with retirement saving plans that combine elements of an Employee Stock Ownership Plan (ESOP) with a traditional 401(k), a substantial fraction of defined-contribution retirement-plan assets are held in company stock. Many empirical evidence shows that company stock has been heavily invested in 401(k) plan. The aggregate data on the share of 401(k) plan assets invested in company stock from 1998 Form 5500 filings, as reported in the Pension and Administration (2001), show that 15.1 percent of 401(k) plan assets were held in company stock. A survey by the of Management and Administration (2001) of 220 large firms with defined-contribution plans also found an average of 36.1% of plan assets in company stock. The plans at these large firms, in particular, account for a substantial share of both participants and assets in 401(k)-type of plans.

The fact of large own company stock holding in retirement plans has come under

scrutiny in recent years, in response to the sharp decline in the stock prices of several firms at which employees held a large fraction of their 401(k) plan assets in company stock, including Enron, Global Crossing, Lucent, and Polaroid. At Enron, 57.73% of 401(k) plan assets were invested in company stock, which fell in value by 98.8% during 2001. The decrease in share prices and eventual bankruptcy filing of Enron resulted in huge financial losses for many of its 401(k) participants. Standard portfolio theory also suggests that there are potentially large welfare costs from holding company stock because it raises the volatility of the retirement wealth for employees and expose some workers to the prospect of very small retirement values (Meulbroek (2002), Ramaswamy (2003), and Poterba (2003)). Especially holding an undiversified position in employer stock may be particularly costly because it exposes employees to idiosyncratic risk and introduces a positive correlation between labor income shocks (value of human capital) and company stock returns. When the performance of own company stock is quite poor, the employees face a higher probability to be laid off (Davis and Willen (2000a,b), Campbell and Viceira (1999) and Campbell, Lettau, Malkiel, and Xu (2001b)).

Company stock is a quite risky and heavy invested equity in the 401(k) accounts, but few studies have analyzed what factors cause the employees to hold company stock in a pension account. Most of the studies who analyze this question focus more on the past stock market performance of company stock [1] and the features of the employer-sponsored 401(k) plan[2]. Because of the limitation in the plan-level data, their studies do not analyze any effect from the individual characteristics (age, education, marriage status, risk attitude, and etc.), working experience from the employees (labor supply, tenure, and expected service time), financial information from both the individual and household (spouse's retirement wealth, and household non-pension liquid wealth). However, those factors have important effect on company stock holding. For instance, Holden and VanDerhei (2001) suggest that the company stock holdings in the pension account vary with different age levels. And some studies also point out the risk of

[1]Even and Macpherson (2005) and Benartzi (2001) find that the level of company stock holdings responds positively to recent stock performance. Their estimates suggest that investors overweight recent stock performance, and fail to rebalance portfolios.

[2]Liang and Weisbenner (2002a), using panel data for nearly 1,000 companies during 1991 to 2000, find that the number of investment alternatives offered, and whether the company requires some of the match to be in company stock are key factors of the share of total contributions in company stock.

company stock investment will decrease by increasing the relative size of non-pension wealth (see Meulbroek (2002), Ramaswamy (2003), and Poterba (2003)).

This study provides an empirical analysis of the factors that affect company stock investment in the 401(k) pensions, using the data from the Survey of Consumer Finances (2004[3]). With the survey data, I can include a broad a list of factors into the analysis, not only the employment features, but also the financial wealth information and the individual characteristics. The estimated results suggest that the company stock investment decision in 401(k) account is not only affected by employment characteristics and pension designs, but also depends on individual total asset and wealth decomposition in different types of account.

There are three main findings of this study. Firstly, this paper examine the determinants to the decision of whether to hold any company stock in the 401(k) plan. The estimates suggest that employment status, including the company size, labor supply decisions and employer matching policies in the pension account, plays a positive role in the company stock ownership. In addition, I find that asset decomposition between pension account and non-pension account has significant impact on company stock investment decision. The results indicate that people with lower non-pension wealth are more likely to invest in company stock in the 401(k) account, which is consistent with the findings in Amromin (2003) and Li (2009), who suggest that, because of the precautionary saving motives, individuals with lower wealth outside pension tend to keep safer assets in that account and invest in risky asset inside pension, and, moreover, this effect is more significant in the case of company stock when the labor income is positively correlated with risky asset. The estimates also imply that different from general stock ownership, which is increasing with more risk tolerance and total wealth, the company stock ownership is not influenced by risk preference and decreasing with total wealth, thus suggesting that less wealthy people are those who are more likely to expose to company stock risks.

Secondly, conditional on company stock ownership, I find that the actual company stock amount and shares are not affected by employment features, but depend on asset decomposition in the pension and non-pension accounts. Given all others constant, agents with more 401(k) balance tend to invest a less share in company stocks, which is

[3]The wave 2007 will be added into the analysis soon.

the same for people with more total non-debt wealth. This phenomenon further suggests that, as a special risky type of asset, company stock is more heavily invested by less wealthy individuals.

Thirdly, I analyze the consequences in asset allocations of holding company stock in 401(k) pensions. Since company stock and other stocks are substitute, the company stock investment will decrease the holdings of other stocks in the 401(k) account. But people with company stocks in their financial portfolios are investing more shares of equities in the pension wealth, and are more likely to hold full-equity portfolio in the pension assets. The evidence found by this study suggests that the current overall portfolio choice by the agents with company stock investment is quite risky.

The rest part of this paper is organized as follows. Section 2 provides a description of the data from SCF. The estimation and results are discussed in Section 3, and conclusion is drawn in Section 4.

2.2 Data

The data set I use is one wave from the Survey of Consumer Finances (SCF), collected in 2004. The surveys are conducted by the Board of Governors of the Federal Reserve System and cover a substantial cross-section of U.S. households in each survey year. There are 4519 households and 9038 individuals in the survey studied here. The survey ask a wide array of questions on every aspect of household financial situation—amount and type of liquid and illiquid assets, nature and value of proprietary business holdings, availability and price of credit, sources of earnings, and so forth. Of particular value for studies of household portfolio composition is the fact that the SCF oversamples wealthy households, which tend to have richer portfolio structures. Each survey makes available a set of sampling factors that allow one to re-weight the sample to produce population statistics. Unless otherwise noted, all descriptive statistics utilize population weights.

Compared with previous wave in SCF and other surveys, SCF 2004 uncovers precise composition of household financial portfolios, including the information of own company stock in both liquid and illiquid assets. To analyze the exact amount of company stock holding of each respondent, I have to treat each observation as one individual rather than one household. In the survey of this study, 1386 individuals have 401(k)-

Table 2-1: Variable Names and Descriptive Statistics

Variables	Description	Mean	Std. Dev.
Asset allocation in 401(k) plan			
Equity	Equity amount in 401(k) plan ($1000)	33.79	94.29
Equity share	Equity amount / blance in 401(k)	0.546	0.382
Company stock	Own company stock amount in 401(k) ($1000)	4.564	29.28
Company stock share	Own company stock amount / balance in 401(k)	0.065	0.176
Working Environment and 401(k) plan characteristics			
Company size (≥ 500)	No. of employees is more than 500	0.577	0.494
Company size ($100-499$)	No. of employees is 100–499	0.184	0.388
Company size ($10-99$)	No. of employees is 10–99	0.201	0.401
Company size (<10)	No. of employees is less than 10	0.038	0.190
Wages	Yearly wage($1000)	71.03	168.1
Weeks	Weeks worked per year	51.17	3.582
Tenure	Years worked in this company	10.34	9.050
Providing match	"1" if employer provides some match	0.290	0.454
Employer match rate	Employer match for $100 employee's contribution	21.04	40.49
Investment choice	"1" if self-reported having participant direction in 401(k)	0.730	0.444

type plans and are still working, among which 179 families have two observations, and 397 participants have multiple retirement plans. While company characteristics, working experience, pension accounts, and individual characteristics are reported for each observation, non-pension wealth is collected on a household level. Table 2-1 and 2-2 describes the statistics of the variables I use in this study.

The variables can be divided into four categories. Those are information within 401(k) account, other pension and company characteristics, individual demographics, and household asset value. In 401(k) account, similar to the other empirical studies of DC plans, most of the participants hold a positive amount of equity. Figure 2-1 shows the distribution of equity share in 401(k) plan. Among the observed group, more than 80 percent of the sample holds some stock in 401(k) account, and more than 30 percent invests all account balance in risky assets. Most of the participants put 401(k) assets in three ways, all in safe assets (like bonds), all in risky assets (like bonds), and split evenly

Table 2-2: Variable Names and Descriptive Statistics (Continued)

Variables	Description	Mean	Std. Dev.
Asset location			
Balance 401(k)	In $1000	56.51	133.8
No. of pension	No. of pension plans	1.317	0.518
Have IRA	"1" if having IRA	0.321	0.467
Have DB	"1" if having a DB plan	0.041	0.199
Non-401(k) pension[1]	Household retirement wealth excluding 401(k) balance of the respondent ($1000)	70.15	170.1
Non-pension wealth[2]	Household non-pension financial wealth ($1000)	238.8	913.2
Financial wealth (Fin)[3]	Sum of non-pension and pension wealth ($1000)	238.8	913.2
401(k) share	Ratio of 401(k) balance to all household financial wealth	0.414	0.314
Net worth[4]	All wealth minus debt ($1000)	546.9	2385.
Demographics			
Age		43.49	10.87
Male	"1" if male	0.546	0.498
High school	"1" if have high school diploma	0.249	0.433
Some college	"1" if have some college education	0.173	0.378
college degree	"1" if have college degree	0.534	0.499
White	"1" if white	0.552	0.497
Married	"1" if married	0.752	0.432
Family size		1.069	1.170
Risk Aversion[5]	Self reported risk tolerance	2.856	0.794

[1] Non-401(k) pension wealth include non-401(k) pension wealth of the respondent, such as IRA and DB plans, and pension wealth of the spouse if married.

[2] Non-pension wealth is the sum of cash, bonds, bills, stocks, and mutual funds within a household, except for the part in any pension account.

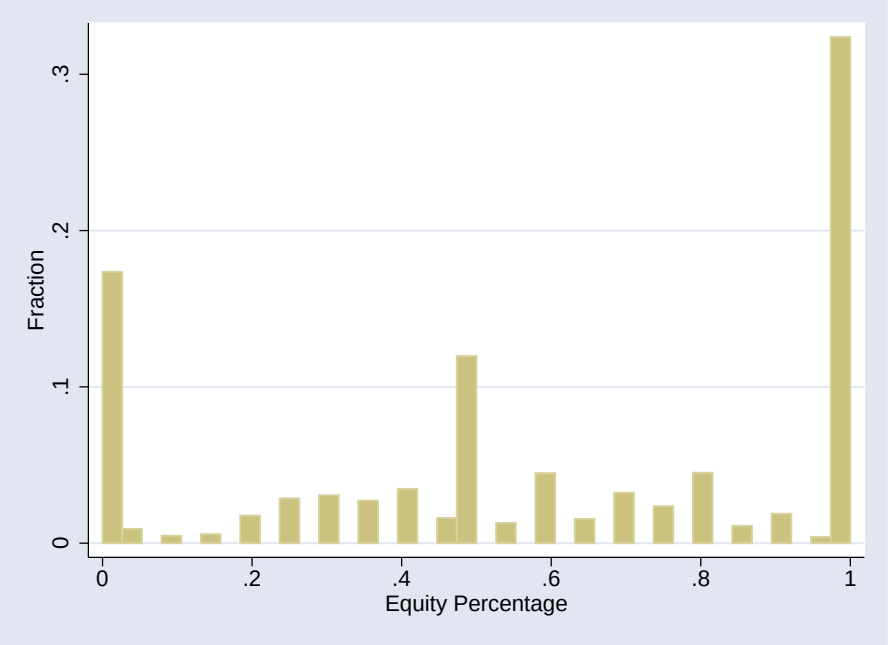
[3] Financial wealth is the sum of non-pension wealth, non-401(k) pension wealth, and the account balance in 401(k) plan.

[4] Net worth is defined as the sum of financial wealth, the value of all proprietary business, housing and other real estate minus various types of debt including mortgages and consumer loans within a household.

[5] Risk Aversion ranges from 1 to 4, a higher value indicating a lower level of risk tolerance.

between bonds and stocks. Compared from stock holding, the observed distribution of company stock looks different. About 18.3 percent of the sample holds some company stock in the 401(k) account, and the distribution of those investors are shown in figure 2-2. Around 15% of this subsample holds more than 50 percent share of company stock in 401(k), and about 35% between 20 to 50 percent share.

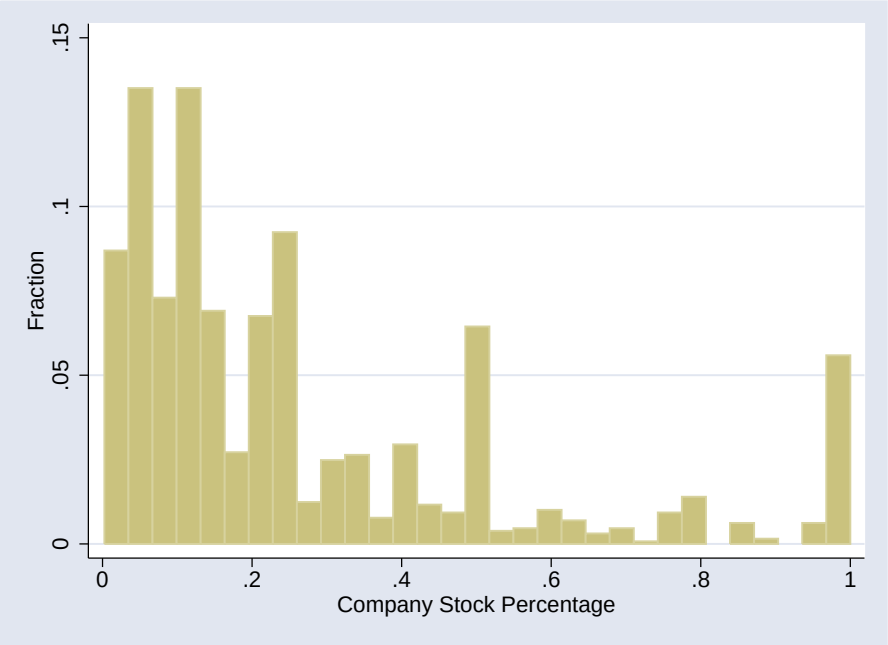
Figure 2-1: Equity Share in 401(k) Account



Among the variables in 401(k) plan, three of them capture the plan characteristics, providing employer match, and employer match rate, and investment choice. Providing employer match is a dummy variable, equal to 1 if the employer matches the employee's first dollar contribution, and zero otherwise. Employer match rate measures the relative size of employer contribution. If the employer matches 2 dollars for every 1 dollar contribution from the employees, then the match rate is 200. Investment choice indicates self-reported value of participant discretion, which equals to 1 when the participant self-reports not restricted by any plan designs.

Generally speaking, in addition to voluntary choices in 401(k) plan, participants are restricted in investment choice to different degrees. Actually, not every participant in 401(k) plan has investment discretion. Some of them face a limited menu of investment funds, and some do not have control over employer contributions. One potential shortage of using SCF is that all the plan features in pension account are self-reported, and the survey does not fully distinguish the effect of different plan designs. For instance,

Figure 2-2: Company Stock Share in 401(k) Account



the survey has question asking whether the employee in 401(k) has investment choice over assets. The answer to it is "yes or no". But the respondent can evaluate investment choice in different way. Some answered "no" because they think the investment options provided by the employer is not well-diversified, while others only because they do not have any control over employer contribution (mandatory company stock match). Therefore, what I can analyze in this study is the role of participant discretion in 401(k) plan.

To analyze the special feature of own company stock, I show the different characteristics between the group with some company stock investment in 401(k) plan and the group without any holding in Table 2-3. Based on the first moment, there is no much difference between the two groups in wages, financial wealth (sum of pension and non-pension), and most individual characteristics (like age, gender, education, and risk aversion), but they do have different levels of business and housing, consequently the total net worth. The group with company stock holding in 401(k) account have less investment in business and housing, which may result from the background risk of those non-tradable wealth. Two additional types of information are shown in this table. On the one hand, some factors seem to play some role in the employee's decision of holding own company stock, such as plan and company characteristics. For instance, participants with positive company stock holding generally face the plan with employer

contribution, higher employer match rate, more likely with investment choice, and from a larger company. In addition, people with own company stock are likely to have more 401(k) balance, and less non-pension wealth. The higher balance in 401(k) may contribute to some generous respect of the plan features, while less non-pension wealth indicate poorer people are more likely to invest in company stock in pretax pension account. On the other hand, provided having some investment in company stock, investors behave differently with other portfolio choice. We can see from the first moment that the group with positive company stock in 401(k) plan invest more aggressively on risky asset in pension accounts, not only in the absolute value but also the proportion.

As suggested by other studies, employees choose company stock other than general risky assets may result from some special features of the employer and the designs of 401(k) plan. To give the plan characteristics a closer good, so I report the company and plan characteristics across company stock share in table 2-4. The second column is about the variable, company stock, which ranges from 1 to 5, showing the number of employees as 0-9, 10-19, 20-99, 100-499, and greater than 500. The rest of the variables are all about plan features. From the table, it is easy to see people with larger company stock share are more likely to work in lager companies, and receive more generous employer match from the employer. But the investment choice does not show clear pattern in this tabulation.[4]

2.3 Estimation and Results

In this section, I describe the regression results of the impact of different factors on company stock investment in 401(k) pensions. Firstly, I report the probit estimation results of the factors that determine company stock ownership, and compare them with the factors that influence general stock investment. Secondly, conditional on positive ownership, the determinants of company stock amount and shares are discussed. Lastly, I explore the effects of company stock holdings on the overall individual portfolio choices.

[4]The estimation results are shown in the appendix.

Table 2-3: Comparison: With and Without Company Stock Investment in 401(k)

	Company Stock > 0		No Company Stock	
Variables	Mean	Std. Dev.	Mean	Std. Dev.
Asset allocation in 401(k) plan				
Equity ($1000)	44.27	(96.54)	30.52	(93.40)
Equity share	0.702	(0.274)	0.497	(0.397)
Company stock	19.23	(57.80)	-	-
Company stock share	0.273	(0.270)	-	-
Working Environment and 401(k) plan characteristics				
Company size (≥ 500)	0.824	(0.382)	0.500	(0.500)
Company size ($100-499$)	0.120	(0.326)	0.204	(0.403)
Company size ($10-99$)	0.053	(0.225)	0.247	(0.432)
Company size (< 10)	0.002	(0.050)	0.048	(0.215)
Wages	71.40	(102.2)	70.92	(183.8)
Weeks	51.75	(1.769)	50.99	(3.965)
Tenure	11.35	(9.760)	10.02	(8.800)
Employer match rate	27.54	(41.78)	19.01	(39.89)
Investment choice	0.794	(0.406)	0.710	(0.454)
Asset location				
Balance in 401(k)	63.75	(142.1)	54.26	(131.1)
No. of pension	1.453	(0.586)	1.275	(0.487)
Have IRA	0.279	(0.450)	0.334	(0.472)
Have DB	0.034	(0.181)	0.044	(0.205)
Non-401(k) pension	70.39	(157.1)	70.07	(174.0)
Non-pension wealth	103.0	(896.3)	115.0	(791.8)
401(k) share	0.423	(0.301)	0.411	(0.318)
Net worth	419.8	(1566)	586.6	(2587)
Demographics				
Age	43.27	(10.83)	43.56	(10.88)
Male	0.518	(0.501)	0.555	(0.497)
High school	0.262	(0.441)	0.245	(0.430)
Some college	0.199	(0.400)	0.165	(0.371)
college degree	0.523	(0.500)	0.538	(0.499)
White	0.567	(0.496)	0.547	(0.498)
Married	0.740	(0.440)	0.756	(0.430)
Family size	1.024	(1.137)	1.083	(1.181)
Risk Aversion	2.799	(0.716)	2.874	(0.816)

Table 2-4: Company and Plan Characteristics over Company Stock Share Level

Company stock share	Company Size	Investment Choice	Providing Match	Employer Match Rate
0-0.25	4.715	0.813	0.336	25.376
	(0.666)	(0.390)	(0.473)	(47.320)
0.25-0.50	4.747	0.781	0.467	35.800
	(0.633)	(0.414)	(0.500)	(45.978)
0.50-0.75	4.918	0.821	0.527	44.715
	(0.343)	(0.385)	(0.501)	(46.464)
>0.75	4.623	0.716	0.474	28.403
	(0.758)	(0.453)	(0.501)	(42.034)

2.3.1 Company Stock Ownership

Table 2-5 column one displays the Probit estimation results of determinants of company stock ownership in 401(k) pension account. The dependent variable is a discrete choice variable, which is equal to 1 if the company stock holding is positive, and 0 if no company stock investment. The regressors comprise of three categories, including employer features (working environment and 401(k) plan designs), wealth information (asset locating inside pension and outside pension), and individual characteristics (demographics). In column two, I also report the determinants of general stock ownership, as a comparison to company stock holdings.

According to the estimates in panel *A* of Table 2-5, the employer features are important to the decision of company stock ownership. First, the coefficients of company size indicate that the larger the company the respondents work in the more likely they invest in company stock. This result, on the one hand, can be explained by the fact that larger companies are those who are more likely to have a publicly-traded company stock, and on the other hand, the company stocks in large companies tend to be more stable than those in small firms, which in turn are more attractive in investment.[5] Second, the results show that individuals who work more time in a year are more likely to hold own company stock. Since employees tend to connect the company stock performance with their own contribution to the firms, it is reasonable to believe that those who spend a lot of time in the work are likely to investment in their own company stocks. This finding can also give some insight on the study of the relationship between labor supply decision and employee stock ownership plans. Third, I analyze the impact of 401(k) pension

[5]Because of the relative bid financial foundation, Large firms are less likely to file bankruptcy during a bad economic time.

Table 2-5: Probit Estimation Results: Determinants to Company Stock and General Stock Ownership (Marginal Effect are reported)

	Company stock > 0		Stock > 0	
	coef.	s.d.	coef.	s.d.
Working Environment and 401(k) plan characteristics				
Company size (>500)	0.319***	(0.080)		
Company size (100-499)	0.278**	(0.134)		
Company size (10-99)	0.119	(0.111)		
Weeks	0.009**	(0.005)		
Employer match rate	0.031**	(0.015)	0.038	(0.028)
Investment choice	0.014	(0.022)	0.236***	(0.031)
Asset location				
Balance in 401(k) $\times 10^3$	0.015	(0.031)	0.024	(0.035)
No. of pension	0.054***	(0.017)	0.002	(0.021)
Have IRA	-0.038*	(0.021)	-0.016	(0.025)
Have DB	-0.057*	(0.029)	-0.007	(0.055)
Non-401(k) pension$\times 10^3$	-0.042	(0.036)	0.034	(0.032)
Non-pension wealth$\times 10^3$	-0.006*	(0.003)	-0.001	(0.003)
Non-pension wealth^2 $\times 10^{10}$	0.326**	0.143)	-0.039	(0.135)
Net worth $\times 10^6$	-0.746	(1.050)	1.100	(0.633)
Demographics				
Age	-0.013**	(0.006)	0.004	(0.007)
Age^2	0.014**	(0.006)	-0.006	(0.007)
High school	0.149**	(0.085)	0.015	(0.049)
Some college	0.185**	(0.095)	0.013	(0.053)
College degree	0.104*	(0.050)	0.005	(0.050)
Male	-0.035	(0.026)	-0.070***	(0.025)
White	0.010	(0.026)	0.066**	(0.030)
Married	0.010	(0.023)	0.072***	(0.029)
Risk aversion	-0.005	(0.012)	-0.074***	(0.015)
Adjusted R^2	0.1537		0.1286	

Significance level: *** 1%; ** 5%; * 10%.

characteristics on company stock ownership. The employer matching rate has a significant positive effect, and a one percent increase in the matching rate can increase the probability of holding company stocks by 0.031 percent. This result is consistent with the empirical results discussed in Benartzi (2001) and Liang and Weisbenner (2002a), who show that employer company stock matches cause participants to hold more company stocks in the pension account. Li (2009) also find theoretical evidence that when labor income is correlated with stock returns, employer matching policy can boost the stock ownership in the pension account. However, the investment choice coefficient, although positive, does not indicate significant effect on company stock holding probability. Different from the effect on company stock ownership, the investment choice variable has a significant positive impact on general stock ownership, which is similar to the results in Papke (2004) who find participant-direction in DC pensions boosts the equity investment in that account. This finding can be explained by the fact that people with freedom in the investment decisions are more likely to choose equities for the higher returns, but they do not prefer company stock because of its potential high risks from the positive correlation with labor income.

In addition to employer characteristics, company stock ownership is also significantly affected by asset location decisions. Because of the rapid growth of self-directed individual retirement account, people not only have assets saved in the conventional taxable account, but also lots of wealth in the pension account. The level of wealth and the proportion of pension assets out of total wealth should have some effect on overall portfolio choices to certain extent. Panel *B* of Table 2-5 illustrates the role of asset location in company stock investment decisions. From the estimates, one can analyze those effects from four directions: employer-sponsored DC pensions, non-DC pensions, and non-pension wealth. First of all, the employer-sponsored DC pensions are captured by two indicators, one of which is the balance in 401(k) account, and the other is the number of pensions the individual may have. The estimates show that although 401(k) balance has a positive but insignificant effect on company stock ownership, the number of employer-sponsored pensions plays a significantly positive role in that decision. It shows that adding one more pension account increases the probability of holding company stocks by 5.4 percent. This results can be interpreted as that the higher number of pensions imply the more generosity of employer policies, which in turn make employ-

ees more likely to hold company stocks. Second, the non-DC pensions, both IRAs and Defined Benefit (DB) plans, have a negative effect on company stock ownership. The availability of other retirement saving account (IRA) provide more retirement saving opportunities, thus making individuals less likely to choose company stock. And the accessibility to DB plans makes the DC account less attractive, therefore reducing the incentive in the investment. The same effects can also be found on the general stock ownership (column 2 in Table 2-5). Lastly, I find that, conditional on the fixed pension wealth, a lower non-pension wealth implies a higher probability to hold company stock in 401(k) account. This phenomenon is consistent the theoretical prediction in Amromin (2003) and Li (2009), who suggest that because of the precautionary saving incentives, people with lower taxable (non-pension) wealth would like to hold safe assets outside pension and hold more risky asset in the pension account. They also point out that when the risky asset return is positively correlated with the labor income shock, like the case of company stocks, people tend to hold even more equities in the pension account. Moreover, the coefficient of new worth reinforce this fact by showing that people with lower total wealth level are more likely to invest in company stock, which is opposite to its effect on general stock such that wealthier individuals are more likely to invest in equities.

At last, I analyze the effect of individual characteristics on company stock ownership in 401(k) plans. It is reported that company stock ownership is decreasing with age, with a increasing speed (the coefficient of age^2 is significant and positive). This results is consistent with the literature about the age-pattern of company stock holdings. For instance, Holden and VanDerhei (2001) find that 401(k) participants between the ages of 20 and 29 hold an average of 15.4 percent of their 401(k) in company stock, compared with 19.7 percent for workers between the ages of 40 and 49, and 16.3% percent for workers over the age of 60. In addition, education experience at and above high school seems to have significant influence on company stock ownership, which may reflect the fact that higher-educated people are more likely to work in public-traded companies and can enjoy company stock benefits. Among the different education groups, individuals with college degree have the lowest probability to invest in company stock. The explanation of this finding may be that college graduates (and above) have realized the high riskiness of company stock holdings. Moreover, there is another implication from

the coefficient of risk aversion indicator. Since a higher number represents a lower level of risk tolerance, the negative coefficient in the stock ownership regression suggests that risk averse people are less likely to invest in risky assets. However, this variable does not have significant effect on company stock ownership, which tells us that risk preference is not one of the main reasons by which people choose company stocks.

2.3.2 Conditional Company Stock Holdings

I explore the factors that influence company stock ownership in the last section, and in this section, I analyze the determinants to company stock amount and shares in 401(k) pensions conditional on a positive company stock investment. Table 2-6 displays the estimates of OLS regressions of company stock amount (column one) and share (column two) on a list of characteristics. The estimated results still comprise three panels: employer features, asset allocation information, and demographics.

The effects of employer features are displayed in Panel *A*, which includes the coefficients of employer matching rate and investment choice in 401(k) plan. Different from the results of company stock ownership, both of the two variables do not display significant effects on conditional company stock holdings. This finding tell us account characteristics in 401(k) pension influence the individual decision of whether to invest in company stock, but not the actual amount of the company stock they held in that account.

The estimated results in Panel *B* indicate that the wealth levels of the individuals and the decomposition between pension account and non-pension account have significant effects on how much company stock invested in 401(k) plan. First of all, wealthy people who have more savings would like to hold a higher amount of company stock. Given others constant, the estimates show that individual who has more non-pension wealth and other pension alternatives (IRA nd DB plans) will investment more money in the company stock. However, since people with more assets will also increase the investment in other type of equities too, this change may not increase the share of company stock investment. The findings suggest that people with more balance in 401(k) account actually hold less proportion of its asset in company stock. The coefficient of 401(k) balance shows that an $1000 increase in the assets reduces the company stock share by 7 percent. Since company stock is a special risky type of asset, it is reason-

Table 2-6: Determinants to Company Stock Investment (Conditional on Positive Company Stock Holding)

	Company stock Amount		Company Stock Share	
	coef.	s.d.	coef.	s.d.
401(k) plan characteristics				
Employer match rate	10.49	(6.941)	0.043	(0.042)
Investment choice	-2.339	(4.675)	-0.046	(0.046)
Asset location				
Balance in 401(k)$\times 10^3$	25.11	(21.04)	-0.077***	(0.029)
No. of pension	13.37	(9.451)	0.056*	(0.031)
Have IRA	19.83***	(7.159)	-0.040	(0.043)
Have DB	106.7*	(57.68)	0.156	(0.113)
Non-401(k) pension$\times 10^3$	0.010	(0.022)	0.097	(0.066)
Non-pension wealth$\times 10^3$	0.001***	(0.000)	0.002***	(0.000)
401(k) share	43.21***	(13.63)	0.003	(0.057)
Net worth$\times 10^3$	-0.171	(0.273)	-0.002***	(0.000)
Demographics				
Age	-1.717	(2.127)	-0.002	(0.014)
Age^2	2.984	(2.661)	0.006	(0.015)
High school	17.08**	(8.099)	0.077	(0.081)
Some college	13.88*	(8.042)	0.107	(0.082)
College degree	25.07***	(8.367)	0.106	(0.083)
Male	3.927	(6.339)	-0.026	(0.038)
White	0.435	(7.277)	-0.046	(0.037)
Married	7.275	(7.755)	-0.005	(0.041)
Risk aversion	-12.04	(7.690)	-0.014	(0.024)
Constant	-21.63	(36.72)	0.145	(0.313)
Adjusted R^2	0.4226		0.0932	

Significance level: *** 1%; ** 5%; * 10%.

able to believe that agents might diverse their portfolios when they have more balance in the 401(k) account. Second, consistent with the previous findings, agents who have lower net worth and higher proportion of 401(k) wealth tend to have more investment in company stock. The estimates imply that a decrease of net worth by 1000 dollars would increase the company stock share by 0.2 percent. In addition, an increase of one percent of 401(k) share out of total wealth would increase the company stock investment by about 40 dollars. Those results further suggest that less wealthy individuals hold more proportion of 401(k) wealth in company stock, which may tend to increase the riskiness of their retirement wealth.

Panel 3 in Table 2-6 display the coefficients of individual characteristics. Among all the variables, only education levels have significant effects on company stock amount, which reflect the fact that, given all other factors constant, higher-educated people may have a deeper insight of the company development, thus they hold more company stocks.

2.3.3 The effects of Company Stock Investment

Table 2-7: Estimation Result: The Role of Own Company Stock[1,2]

	Company stock amount		Company stock share	
Dependent variables	coef.	s.d.	coef.	s.d.
Amount of Equities other than company stocks	-0.621***	(0.215)		
Share of Equities other than company stocks			-0.494***	(0.041)
Amount of All equities	0.380*	(0.215)		
Share of all equities			0.506***	(0.041)
100% equity investment in 401(k) (dummy)			1.363***	(0.223)
Share of 401(k) to retirement wealth			-0.020	(0.046)
Share of 401(k) to financial wealth			-0.035	(0.042)

[1] Significance level: *** 1%; ** 5%; * 10%.
[2] All regressions are controlled by company and plan characteristics, demographics, and household financial information.

Since company stock is a special investment opportunity, many studies try to analyze the consequences in total portfolio structure after holding company stocks. Some

empirical evidence shows that higher employer stock holding reduces the investment in other stocks (Even and Macpherson (2005), Heaton and Lucas (2000), Pratt and Zeckhauser (1987), and Kimball (1990, 1993)), but these studies only focus on the non-pension assets. In this section, I try to explore the effect of company stock holdings in the 401(k) account on the asset allocation and location decisions, which includes the decision of how much savings in the pension account and non-pension account, as well as how much equity to hold in each account.

Table 2-7 shows the impact of company stock holdings on the individual portfolio choices and wealth allocation structure. After controlling for employer features, wealth information and individual characteristics, my preferred estimates indicate that a higher company stock holdings in 401(k) account significantly reduce other stock investment, which is reasonable because company stock and other stocks are close substitute. More importantly, the results suggest that the company stock holding boost the overall equity holding of each individual, and also increase the probability of 100 percent equities in 401(k) account. The estimate shows that a one percent increase in the company stock share in 401(k) plan would increase the overall equity share by point 5 percent, and the probability of full equity holdings in 401(k) account by 1.363 percent. I conjecture that this effect may result from good performance of the financial market during the survey years.

2.4 Conclusion

This paper explores the factors that affect company stock investment decisions in the 401(k) pensions. I empirically analyze the effects of employment features, wealth information and individual characteristics on company stock ownership, conditional company stock amounts and shares. The estimated results suggest that employment status, such as company size, labor supply decisions and pension plan designs, has significantly effect on the decision of whether to hold company stock, but does not significantly influence the actual amount individuals invested. The wealth decomposition in pension and non-pension account plays an important role in the company stock investment in the pension account. In particular, I find that people with lower non-pension wealth are more likely to hold company stock in the pension account, and those with lower 401(k)

balance and total non-debt wealth tend to hold less wealth in company stock. The results imply that less wealthy individuals are those who are more likely to get impacted by company stock risks.

Since less wealthy people who heavily invest in company stock in their 401(k) pensions have a higher risk to lost their retirement wealth, this study provides some evidence that highlight this risk, thus raising the question of whether and how to modify the pension policies that boost company stock investment in the pension account. Future studies can closely evaluate the role of each 401(k) design on the individual asset allocation decisions, and the possible welfare loss (or gain) from the modification of those policies. This type of analysis might be done in a theoretical model with saving and portfolio choices. This study can also contribute to the question of how much investment autonomy should be allowed in the pension account.

Chapter 3

Investment Choice and Savings in Defined Contribution Pensions

3.1 Introduction

The defined contribution (DC) pension plans, especially the striking growth of 401(k) plans, have vastly expanded the number of individuals with some discretion regarding their retirement assets. Self-directed individual retirement accounts will become increasingly common as traditional defined benefit plans are supplemented with or replaced by defined contribution plans. Many state and local governments, traditional defined benefit providers, are considering adoption of 401(k)-type plans. In particular, the behavior of participants in individual retirement accounts can inform the questions concerning the degree of individual autonomy that should be allowed in the proposals to privatize all or part of the U.S. Social Security program.

In the traditional defined benefit (DB) plan, participants are automatically included after meeting a participation standard, and they typically do not make participation, contribution, or investment decisions. Their pension benefit is based on earnings history and years of service. In contrast, defined contribution plans require an employee contribution, typically on a pretax basis under the provisions of Internal Revenue Code section 404 (k). Employers then match some or all of the employee contributions. The combined employee and employer funds are placed in an individual account for the employee, and can be invested in a variety of ways. Participants usually direct the investment of their own contribution, and often that of their employer.

According to the release of U.S.Department of of Labor (2001), about 82 percent (28.2 million) of the 34 million participants in 401(k) plans had some control over their investments. These participants owned over $1.04 trillion in assets, accounting for 83 percent of 401(k) assets. Asset allocation choices that participants make, or that their employers make for them, can determine in part the rate of return on retirement assets, and therefore the adequacy of retirement income. Once employees have initiated participation in the 401(k) plan, the choice that has the greatest direct impact on asset accumulation is how much is contributed to the plan. In this study, I intend to use Health and Retirement Study (HRS) to estimate the impact of investment choice on participants' contribution levels in DC Pensions.

In most studies, people who report that they have control over assets allocation in pension plans do not distinguish the choice between the participant contribution and the employer contribution. Actually, it was common for the employer's contribution to be constrained–often to company stock. Wiatrowski (2000) summarizes the investment choice for full-time employees using the Bureau of Labor Statistics National Compensation Survey. He reports that, in 1985, 90 percent of full-time employees had investment choice over their own contribution, and 48 percent had control over their employer's contribution.[1] In many DC plans the employer contribution is made in company stock, so the effect of investment choice on savings in pension plans would be overestimated if employees do not have control over the employer contribution. In this study, beyond estimating the general role of investment choice on individual behavior in retirement accounts, I will distinguish the impact of unconstrained choice from the constrained one in company stock.

Using the first wave from Health and Retirement Survey (HRS),[2] I find that participants with investment choice contribute over three percentage points more of their salary into the DC plan than people without choice, and people constrained in their investment contribute about three percentage points less in their retirement saving account. Male and lower income participants are more likely to be affected by the ability to direct individual accounts. In addition, the impact of investment choice is also significant in the effort to encourage participants making a positive contribution rather than

[1]Possibly as a result of Section 404(c) regulations, by 1997, there was a slight drop in the percentage of who could control their own contributions (87%), but over 65 percent had choice over their employer's contribution.

[2]The study will be extended to include all the waves in HRS.

zeros.

The next section presents the literature background of the previous studies. Section 3 briefly summarizes the data used in this analysis. Section 4 presents an econometric model and discusses the possible endogeneity of the asset choice variable in the analysis. Section 5 provides econometric evidence on the effect of investment choice on participants' contribution levels. Section 6 concludes with implications of the findings for pension policy and for individual accounts proposed for Social Security System.

3.2 Literature

Plan designs have strong effects on employee contribution choices (see a recent review by Choi et al. (2004)). A handful studies have considered plan-level attributes that affect participation and contribution levels in such plans, but the impact of investment choice on contribution rates has only recently been examined in the literature, and the results are limited.

Cunningham and Engelhardt (2002) find that the ability to direct investment of the voluntary balance is associated with very large increase in 401(k) savings, but they only raise the phenomenon and do not give detailed explanation. Papke (2004) use two data sets to estimate the role that participant investment choice plays in asset allocation, contributions and account balances. He finds that the ability to exercise choice over investment allocations in defined contribution plans increases contribution rates by one to three percentage points relative to the contribution rate that would be chosen in the absence of participant direction. The investment options referred in Papke (2004) are a combination of both constrained and unconstrained choice.

In contrast to the positive effect of participant investment choice, the effect of the company stock investment in the pension plans is quite controversial. Huberman (2001) argues that company stock guarantees the presence of a familiar option in the menu, so familiarity breeds investment. The same result is also given by Huberman and Jiang (2006). However, many other studies show evidence that the presence of company stock increases the risk, and therefore reduces the retirement savings, for instance, Huberman and Sengmuller (2004), Liang and Weisbenner (2002b), and Ramaswamy (2003).

In this study, I define the participant investment options as constrained if the in-

vestment is required to invest, mostly or partially, in company stock. Isolating the constrained choices from the unconstrained ones is important at least for two reasons. On the one hand, there would be an upward bias in the estimation of the impact of investment options on individual saving behavior, for the employee would report having choice even if the employer directs the firm's contributions. On the other hand, the effect of the company stock requirement in the investment on contribution levels would be overestimated without the differentiation, since some employees still have control over their own retirement savings. These problems will be explained in detail in the following sections.

3.3 Data

Although plan-level data set is a good tool to study the effect of plan design factors, most of them cannot be used to analyze the impact of investment choice, since, within each employer-sponsored pension plan, participants either all have a choice in assets investment or they all do not. A survey data set will be able to overcome this problem, since it includes participants in the DC plans both with investment choices and without the choice. In this study, I use the first wave from Health and Retirement Survey (HRS), a biennial household survey that started in 1992 until now. In addition to detailed demographic data on the respondent and her household, supplementary questions on his/her and his/her spouse's pension eligibility and benefits from current/past employers or from other pension sources were included in the questionnaires.

Each series gathered detailed information on participation in up to three defined benefit and/or three defined contribution pension plans offered by an employer. For those participating in defined contribution plans, information includes the type(s) of plan (e.g. thrift/savings, 401(k), profit sharing, stock purchase, or other), dollar amounts that both employer and respondent contributed and the employee's contribution percentage, account balance, and how the dollars were invested. Specifically, respondents were asked: Were you able to choose how the money in your account is invested? How is the money in this account invested? Is it mostly in stocks, mostly in interest-earning assets, is it split evenly between these, or others? The three responses are-mostly or all stocks; mostly or all interest-earning assets; split evenly between the two.

Because the survey is of the older population, the sample is not representative of the pension age population in the U.S. In particular, the sample is older, so that analyzing these data may not tell us about retirement savings of younger people. Still, this is an interesting group to look at since these people, nearing the end of their professional careers, are likely to have pensions and to consider retirement income seriously.

Some features of the reported contribution level in the data set should be emphasized. Firstly, many employers providing pension plans impose a default level of contribution rate to the employees, that is, participants who decide to participate in the DC plan should automatically contribute the default rate of their salaries.[3] Without this information, it prevents us from measuring the real contribution rates of the participants who desire to contribute between zero and default rate. There is no study in the literature of pension contribution rates considering this problem by now, so this part would be worth extended if with complete data set. Secondly, the employer-sponsored defined contribution plans usually impose a maximal level of employee's contribution rate. In that case, if the participant contributes the maximum amount, his/her desired contribution level may be higher than his/her reported contribution rate. A censored regression of the max-out amount has been studied by Huberman and Jiang (2006), using a plan-level data set. In addition, employer usually provide some match to the employees contribution, but only up to a limit percentage of pay. This limit is called match threshold. Many participants save in the retirement account only to the match threshold amount, since the match rate is considered as the initial rate of return. However, HRS does not include such questions that can capture the default contribution level requirement, the maximum contribution rates and match threshold.

Despite of the above restrictions imposed upon participant contribution level, people can still control their contributions voluntarily in several ways. First, they can usually decide whether to contribute a positive amount or not. Second, they can choose any amount between the default and the maximum contribution rates. In addition, they can contribute more than employers match threshold. In this study, I primarily focus on the first two aspects.

The investment choice variable of pension assets adopted here is the reported information by the respondents themselves in HRS. This is the one not distinguishing

[3] In a recent survey, Hewitt Associates (2001) reports that 14 percent of companies utilized automatic enrollment in 2001, up from 7 percent in 1999.

between constrained and unconstrained control over pension investments. I also include a dummy variable indicating that the participants are constrained in using their own contributions or their employers' contribution. That is usually the case of profit-sharing and company stock purchase plans, in which the employers' contributions are constrained in company stock, as well as the employees' contribution sometimes.

In the 1992 HRS, there are 2277 non-retired respondents who have at least one pension plan, among which 20.9% people report that they participate in a defined contribution plan. I restrict the sample to participants in DC plans, and to those who respond to the investment questions. This reduces the sample to 476 individuals. Table 3-1 reports summary statistics for the sample of respondents with DC plans, the subsample of people with positive contributions to individual account, and those with zero contributions, respectively.

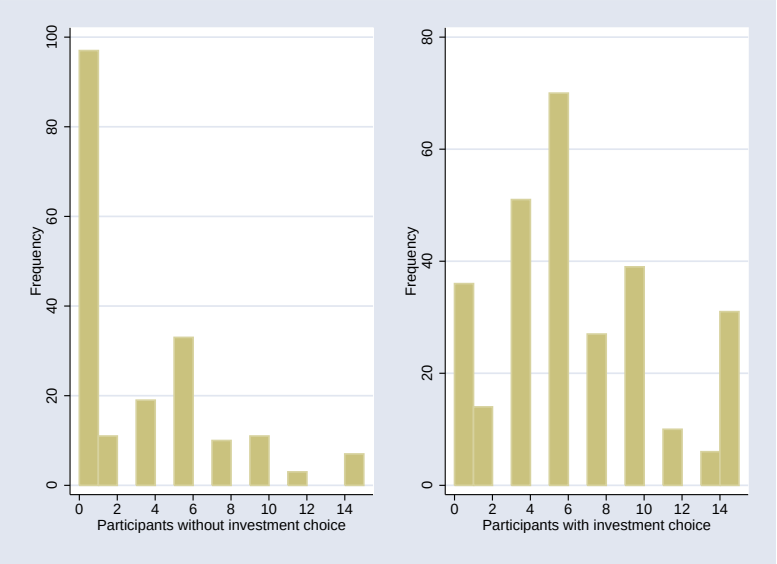
In the full sample, the participants averagely contribute 5.99 percent of their salary into the DC account, and the average contribution amount is about 1.84 thousands dollars per year. The average account balance is $31,080 by the survey year. Investment choice is available for 60 percent of the participants, and 16 percent of them have a profit-sharing or stock purchase component, that is, the employees do not have perfect control over the employer's contribution. Women comprise 47 percent of the sample, and over 80 percent of the sample are married. In addition, about 27 percent of the respondents have a defined benefit plan together with a DC plan.

Compared with the subsample of participants with zero contributions, the subsample with positive contributions display more ability in controlling investment of pension funds, that is, 71 percent of this subsample have choice of pension assets, while only 28 percent have this choice in subsample with zero contribution. People with positive contributions are also less constrained in company stocks, and they are associated with more income and less employer contribution rate, which is defined as the ratio of employer's contribution to the employee's salary.

Figure 3-1 shows the distribution of contribution levels in DC plans of the participants with investment choice and without the choice, respectively. Generally speaking, participants with the ability to direct investment save more in the defined contribution plans, and, specifically, compared with the group without choice, there is a large drop among the respondents who contribute zero amount, and a remarkable increase of the

people who save more than 15 percent of their salaries. This graph indicates that investment choice encourage the saving rates in the defined contribution plan. [4]

Figure 3-1: Distribution of Contribution Rates (%)



3.4 Model and Estimation

3.4.1 Basic Regression

The primary dependent variable is the annual contribution as a percentage of salary.[5] I use y_{ij} to present the contribution rate of individual i who enrolled in pension plan j. Specifically, the employee's contribution is described by a function of choice variables $Choice_j$, a set of individual characteristics X_{ij}, and other plan policies Z_j,

$$y_{ij} = \alpha_0 + \alpha_1 Choice_j + \alpha_2 X_{ij} + \alpha_3 Z_j + \varepsilon_{ij}, \varepsilon_{ij} = u_j + v_{ij}. \tag{3-1}$$

The asset choice dummies comprise three parts— choice dummy of pension investment, constrained choice dummy of investment in company stocks, and one of these two

[4]The distribution of contribution rates provided here is more or less the same as the ones shown in other studies (See Choi et al. (2004), and Huberman and Jiang (2006) for reference). The non-normal distribution of the contribution percentage may come from the fact that default rate and maximum rate play a role in the individual's saving decision.

[5]In this study, I focus on the participant contribution rates in defined contribution plan other than the actual contribution amount. The reason is that most plan policies are designed upon contribution percentage, but not the absolute amount in dollars, such as default contribution rate, maximum contribution rate, and employer match rate. An exception is maximum amount imposed by government, and it is only effective for highly compensated workers. Further, the coefficients in the analysis do not change their fundamental economic importance when I use contribution amount as the dependent variable.

Table 3-1: Summary Statistics

	Full Sample in DC plan	Subsample with Positive Contributions	Subsample with Zero Contributions
Variable	Mean(S.D.)	Mean(S.D.)	Mean(S.D.)
Contribution percentage	5.99	8.08	0.00
	(7.81)	(8.09)	(0.00)
Contribution amount	1.84	2.49	0.00
($1000)	(2.57)	(2.70)	(0.00)
Account balance	31.08	27.46	41.47
($1000)	(56.12)	(50.25)	(69.49)
Investment choice	0.60	0.71	0.28
	(0.49)	(0.45)	(0.45)
Constrained choice	0.16	0.11	0.31
in company stocks	(0.37)	(0.31)	(0.46)
Employer contribution	8.71	7.70	11.62
rate	(17.45)	(13.20)	(25.90)
Female	0.47	0.49	0.40
	(0.50)	(0.50)	(0.49)
Married	0.82	0.81	0.82
	(0.39)	(0.39)	(0.38)
Age	54.09	54.22	53.72
	(4.74)	(4.66)	(4.97)
Education	13.18	13.13	13.30
	(2.63)	(2.67)	(2.50)
White	0.88	0.88	0.86
	(0.33)	(0.32)	(0.35)
Black	0.10	0.08	0.14
	(0.30)	(0.28)	(0.35)
Years in DC plans	7.96	7.05	10.55
	(7.44)	(6.68)	(8.83)
Annually income	33.29	32.52	35.52
($1000)	(21.77)	(22.93)	(17.95)
Net worth	217.68	214.75	226.04
($1000)	(408.93)	(428.42)	(348.85)
Has a DB plan	0.27	0.21	0.43
	(0.44)	(0.41)	(0.50)
Years in DB plan	2.37	2.35	2.46 5
	(6.59)	(6.36)	(7.25)
Has an IRA	0.01	0.00	0.02
	(0.09)	(0.05)	(0.15)
No. of observations	476	353	123

variables interacted with each other. Therefore, the coefficient of the investment choice alone shows the effect of investment choice unconstrained by any plan designs, the coefficient of constrained choice reflects the size of the impact of no investment choice over any employer's and employee's contribution, and the influence of the limited choice are measured by the sum of all three components in α_1.

X_{ij} comprises individual characteristics like age, gender, education, race, and marital status. Z_j includes employer contribution rates ,[6] industry occupation, and firm size dummy variables, which are considered as employer's generosity that encourage the employees to save in the retirement account. The disturbance term can be decomposed into a plan-specific unobserved effect, u_j , which is assumed uncorrelated across different plans, and an individual disturbance, v_{ij} , assumed independently distributed across individuals. Both u_j and v_{ij} could be heteroskedastic across plans or individuals, but are assumed to be independent of the regressors.

One might argue that asset choice is an endogenous variable in the regressions. There are three main sources of the endogeneity. First, participants with some financial sophistication and taste for saving join the firms that offer plans with investment choice. However, Papke (2004) demonstrates that investment choice is not endogenous by showing the plan knowledge obtained by the employees is not correlated with asset choice variables. In addition, participant direction in asset investment may also be related to unobserved plan features, u_j , that increase savings. Absent much detail on plan features, I include employer contribution rates, industry occupation, and firm size dummy variables, since generosity of benefits is known to increase with firm size. Moreover, there might be a correlation between investment choice variables and unobserved heterogeneity, v_{ij} ,that reflects saving propensity. So I have tried to include enough individual characteristics correlated with saving propensity to control for any unobserved heterogeneity, such as the ownership of an IRA and participation in a DB plan. An alternative to address the endogeneity issue is to find an instrumental variable for asset choice, but none suggests itself in this data set.

[6]Employer match rate should be the best indicator of employer's generosity that encourages the employees to contribute positive amount, since it becomes effective only if the participants contribute nonzero amount. However, HRS data set does not provide the information of employer match rate. Employer contribution rate is far away an effective measurement of the match rate. I use this term in the second step other than the first one because it has nothing to do with the probability of positive contributions. If we run the first part with employer contribution rate as one variable, the coefficient is -0.007, and can be rejected even with 10 percent significant level.

I focus on the sample of people who enrolled in defined contribution plans. One may argue that this sample may subject to selection bias because people who are more sophisticated in financial investment or who are more likely to save might have more chance to contribute to a defined contribution plan. But the evidence from the data shows that there would be no or very small selection bias in the saving intensive. First of all, the participation rate is the percentage of people who voluntarily enroll in a DC plan given that their employers provide them this option and they are eligible to enroll in it. I collect a sample of 705 participants who are self-reported eligible to attend a DC plan. The participation rate of defined contribution plan is 67 percent among this sample .[7] But the other 33 percent respondents outside DC plans do also have the intensive to save, such as 60% of them intend to participate in a DC plan in the future, 89% of these people save in the form of IRA , or simply by Social Security System (almost everyone).

3.4.2 Two–Part Decision

Participants' involvement in the DC plans has several levels, such as whether to contribute a positive amount, and how much contribution to make after that. So I provide a two-part regression to analyze the investment choice effect separately. The dependent variables in this step are: (1) A dummy variable that equals one if the individual contribute a positive amount; (2) Contribution rates conditional on positive contribution.

Formally speaking, in the first part, an individual i's benefit from contributing in a DC plan j, U_{ij}, can be expressed as a function of choice variables, and a set of individual characteristics X_{ij}, and plan characteristics Z_j, such that,

$$U_{ij} = \beta_0 + \beta_1 Choice_j + \beta_2 X_{ij} + \beta_3 Z_j + \delta_{ij} \equiv W\beta + \delta_{ij}, \delta_{ij} = \eta_j + \mu_{ij}. \qquad (3\text{-}2)$$

W is defined as a matrix of constant, $Choice_j$, X_{ij} and Z_j. The disturbance δ_{ij} can be decomposed in the same way as ε_{ij} . The individual will contribute a positive amount if $U_{ij} > 0$, otherwise not. The impact of investment choice can be analyzed using Probit method.

[7] In 2002, the Profit Sharing/401(k) Council of America reported the national average participation rate as 76%.

In the second step, equation 3-1 will be estimated conditional on the subsample with positive contributions. Since the decision rule selects people into observed classes according to non-zero contribution within DC plans, the contribution rates actually observed are not a random sample of the population, but are truncated non-random samples. Therefore, define the covariance of ε and δ as $\sigma_{\varepsilon\delta}$, and the standard deviation of δ as σ_δ. From equation 3-1, we have,

$$\begin{aligned} E(y_{ij}|U_{ij}>0) &= \alpha_0+\alpha_1 Choice_j+\alpha_2 X_{ij}+\alpha_3\tilde{Z}_j+E(\varepsilon_{ij}|U_{ij}>0) \\ &= \alpha_0+\alpha_1 Choice_j+\alpha_2 X_{ij}+\alpha_3\tilde{Z}_j+E(\varepsilon_{ij}|\delta_{ij}>-W\beta) \\ &= \alpha_0+\alpha_1 Choice_j+\alpha_2 X_{ij}+\alpha_3\tilde{Z}_j+\frac{\sigma_{\varepsilon\delta}}{\sigma_\delta}E(\varepsilon_{ij}|\frac{\delta_{ij}}{\sigma_\delta}>\frac{-W\beta}{\sigma_\delta}) \\ &= \alpha_0+\alpha_1 Choice_j+\alpha_2 X_{ij}+\alpha_3\tilde{Z}_j+\frac{\sigma_{\varepsilon\delta}}{\sigma_\delta}\lambda, \end{aligned} \tag{3-3}$$

where $\lambda \equiv \frac{\phi(W\beta/\sigma_\delta)}{\Phi(W\beta/\sigma_\delta)}$ is the inverse Mills ratio.

The estimation of the two-part regression is possible only if Z_j in equation (3-2) has elements other than $\tilde{Z}_j$ in equation (3-3). In this study, Z_j includes employer contribution rates, industry occupation, and firm size dummy variables, while $\tilde{Z}_j$ only contains employer contribution rates. The reason is that industry occupation, and firm size dummy variables are considered as employer's characteristics only encourage the employees to save in the retirement account but not the amount they save. The estimation result will be analyzed in the next section.

3.5 Econometric Results

This section presents econometric evidence on how investment choice affect contribution levels in DC plans using data from HRS. In the regression, there are 476 individual DC plan participants, with 22 multiple plans for a total of 498 observations. The average percentage contribution is 5.99 percent of salary with a standard deviation of 7.81. The mean of those who contribute is 8.08 percent with a standard deviation of 8.09, while 123 participants report a zero contribution.[8]

[8]Because the typical employer match in DC plans yields a return far exceeding that on alternative investment, participants would be predicted to contribute positively if all individual were fully informed, financially rational, with access to perfect capital markets and no transactions costs. But, as other studies

3.5.1 Results for basic regression

Table 3-2 present OLS regression of the percent of salary the participant contributes to the pension plan. Because about 3.2% of the identifiers have two observations, the standard errors are corrected for within family (identifier) correlation. In addition, I report heteroskedasticity-robust standard errors, for people display different variation in contribution rate at different compensation levels.

The basic regression (column one) includes asset choice dummies, demographic factors, and financial information of the respondents. Employer's contribution rate in the DC plans is estimated in column two, and other plan and IRA dummies are included in column three. The coefficient of investment choice is positive and statistically significant, indicating that people who are able to choose their own investments and not constrained by plan designs contribute 3.25 percentage points (column three) more of their salary into the DC plan than the rest of participants. This result is consistent with that in Papke (2004), who finds that participants with choice contribute over three percentage points more than those without it.

In contrast, the coefficient of constrained choice is negative and significant, predicting a 3.53 percentage points less in the contribution rates for the employees constrained in company stock of both the employer's and employee's contribution, suggesting that people would rather give up their opportunity to invest in the pension plan if they cannot fully self-direct their individual retirement accounts. The following shows one possible explanation. If the employer contribution is made in company stock in the DC plans, this structure may encourage employees to hold extremely risky portfolios. So, for the employees who have fully control over their own contributions, they have two options to balance the risk. One way is to invest less risky assets within the defined contribution plan; the other way is to choose other risk free retirement plans, like the defined benefit plan. But for the employees who have partial or no control over their own contributions, the wise choice would be to reduce the contribution in the DC plan, and resort to risk free pension plans.

It is interesting to speculate by what mechanism choice over one's assets compels participants to contribute more to their pension plans. Thaler and Shefrin (1981) ar-

also point out, there are still some respondents leaving "money on the table" by not capturing the total potential returns. One possible explanation for this is that individuals were liquidity constrained, and this has been analyzed in many studies, for instance, Engelhardt and Kumar (2006).

gue that individuals have conflicting preferences—those of a patient saver conflict with more short-sighted preferences. A change in a pension plan, may tip the internal balance toward the more patient side and simulate saving. The estimates show that having investment choice raises the percent of salary contributed and above the influence of the employer matching rate—the contribution's initial rate of return. It may be that having to choose some or all of your investments causes participants to increase their level of contribution since their asset choices will in part determine their return. This may be in contrast to more passive behavior in plans where employers manage the investment.

The above formulation assumes the effect of assets choice is the same for men and women. When I allow for gender differences (Table 3-3), the significant effect of asset choice for men is 4.01 with a robust standard error of 0.76, and the effect for women is 1.89 with a standard error of 1.11, but not significant in a 95% confident interval. In contrast, the negative effect of the constrained choice variable is significant for women (-5.30 with a standard error of 2.28), whereas this effect is negative but not significant for men (-3.07 with a robust standard error of 2.05). The gender difference suggests that women are less likely influenced by the investment options in their savings to a DC plan, and they are more conservative in the risky asset investment. There are at least two explanations, which are not mutually exclusive. One is that women have a stronger preference for saving, perhaps because they typically live longer than men. Two, the unit of decision is the household, and in many cases women are secondary wage earners whose incomes supplement those of their husbands. In these cases women's recorded incomes are substantially lower than their households' incomes and their behavior is likely to reflect their households' incomes (Huberman and Jiang (2006)).[9]

Income is an interesting individual attributes. The result shows that controlling for all other variables, participants contribute 0.4% more of their salaries into a DC plan for an increase of $10,000 in compensation. There are several reasons behind this fact. First, the progressivity of the income tax code entails stronger incentives of those who earn more to contribute in a tax-deferred plan. Moreover, low-income employees are more likely to have, or anticipate having liquidity contraints which will deter them from contributing large sums to a 401(k) plan, where the money is locked up until retirement. Additionally, low-income employees expect higher salary replacement rates from So-

[9]Nationally, according to Business Week, in 70% of the married households the husbands earn more than the wives.

cial Security upon retirement than high-income employees. This anticipation lowers the desire to save for retirement. Actually, whether those who earn more also save a larger fraction of their incomes has been a well known question, going back decades prior to Friedman (1957) classic work on the consumption function. Recently, Dynan et al. (2004) revisit the issue and conclude that those with higher expected lifetime earnings also have higher savings rates. This study uses the sample of older population (HRS), and savings are narrowly defined as contribution to defined contribution plans, so the result cannot be extended to lifetime saving behavior.

In addition, the effects of individual characteristics, like gender, age, education and marriage, are not significant in this analysis. When I include a dummy of DB plan in the regression (column three), the coefficient is negative and insignificant. This result is consistent with that in Clark and Schieber (1998), who find no difference between the 401(k) contribution rates of participants that do or do not have a defined benefit pension plan.[10] Different from the effect of DB plans, the coefficient of having IRA is significantly negative, which suggests that defined contribution plans and IRAs are substitutes in tax-deferred saving. This result is consistent with Engelhardt and Kumar (2006), who find that the estimated after-tax cross-price elasticity of 401(k) contributions with respect to IRA saving is negative.

I include employer contribution rate in the regression of column two and column three. The coefficient of employer contribution rate is about 0.073 with a P-value of 0.054, indicating a 1% more in the employer contribution rate will lead to a 0.073 percentage increase in the employee contribution rate. I use employer contribution rate instead of match rate in this setting because there are limited number of questions about plan features in the HRS data. Some papers, like Papke (1995), construct an effective match rate equal to the ratio of the employer to employee contribution, but that is not the marginal match rate that applies to the participant's next dollar of contribution. In addition, when I use this treatment in HRS data, the inclusion of the approximated match

[10]The empirical evidence on the impact of defined benefit pensions on DC plan contributions is mixed. Cunningham and Engelhardt (2002) find that non-401(k) pension coverage is associated with substantial reduction (22 to 44 percent) in 401(k) contributions. Munnell et al. (2001) find that conditional on participation, the level of wealth in a defined benefit plan has a negative but insignificant impact on 401(k) contribution rates. In contrast, Huberman and Jiang (2006) find that those covered by defined benefit pension plan contribution slightly more on average to their 401(k) plan. Papke (2004) find that a participant with a DB plan is predicted to contribute about 1.2 percentage points more to his or her DC plan.

rate does not influence the fundamental economic importance of investment choice variable.

3.5.2 The Impact of Variation in Compensation

The defined contribution plan participants are not a homogeneous group. There are a few differences between low and high income employees. One, the tax benefits of saving through a tax-deferred vehicle are more generous to the higher income employees. Two, lower income employees are more likely to face liquidity constraints that will prevent them from putting money away, even in a tax-deferred plan. Three, Social Security benefits offer high salary replacement rates to lower income employees, and render alternative retirement savings less urgent. Four, low income employees may be less educated and sophisticated about the benefits and costs of participating in a 401(k) plan. Huberman and Jiang (2006) find that the low-income employees are more likely to be influenced by plan design factors, like including company stock in the investable funds. Engen and Gale (2000) suggest that the savings behavior varies across earnings groups, and therefore defined contribution plans have different effects on household wealth.

The differences between low and high income employees suggest a reexamination of the data separately for various levels of compensation. In this section, I report in Table 3-4 the estimates from the regression of three groups—lower income (less than 25%), middle income (25%–75%), and higher income (greater than 75%). The ability to direct investment still plays a significant role in the participant contribution throughout three groups, with a slightly higher effect for the lower income respondents, while the constrained choice is only significant for lower income group. The empirical evidence shows that lower income participants will decrease their contribution rates by 4.64 percent if they are constrained in the ability to direct the asset investment, and this negative effect is more likely to be compensated by the asset options (the coefficient of the interacted term is 7.04). This result may come from the fact that lower income respondents are more likely face liquidity constraint, thus they are less likely to put money into extremely risky asset, and therefore, are more likely to be attracted by the self-direction ability in asset options. The same implication can also be derived from the negative and significant coefficient of having other pension plans, which suggests

Table 3-2: Linear Models of Participant's Contribution Rate to Defined Contribution Plan

	(1)	(2)	(3)
Investment choice	3.381^{***}	3.315^{***}	3.251^{***}
	(0.777)	(0.741)	(0.717)
Constrained choice in company stocks	-2.085^{*}	-3.160^{**}	-3.534^{**}
	(1.210)	(1.417)	(1.488)
Investment choice × constrained choice	2.188	2.934	3.218^{***}
	(1.819)	(1.899)	(1.956)
Years in DC plans	0.073	0.073	0.078
	(0.082)	(0.080)	(0.079)
Female	0.970	0.798	0.812
	(0.651)	(0.671)	(0.668)
Married	-0.268	-0.568	-0.663
	(0.945)	(0.924)	(0.932)
Age	0.066	0.062	0.051
	(0.081)	(0.080)	(0.079)
Highest education	0.048	0.073	0.078
	(0.115)	(0.120)	(0.120)
White	1.452	1.408	1.387
	(1.038)	(1.014)	(1.027)
Annually income ($1000)	0.044^{**}	0.046^{**}	0.045^{**}
	(0.022)	(0.023)	(0.023)
Net worth ($1000)	0.001	0.001	0.002
	(0.001)	(0.001)	(0.001)
Employer contribution rate		0.074^{*}	0.073^{*}
		(0.041)	(0.040)
Has a DB plan			-0.723
			(0.706)
Has an IRA			-8.921^{***}
			(2.207)
Industry, occupation, and firm size dummies		Yes	Yes
Constant	-1.079	-1.246	-0.518
	(4.628)	(4.559)	(4.510)
No. of Observations	476	476	476
Adjusted R^2	0.0874	0.1143	0.1255

Significance level: *** 1%; ** 5%; * 10%. Robust Standard Error in parenthesis.

Table 3-3: Linear Models of Participant's Contribution Rate to DC Plan–Gender Differences

	Male	Female
Investment choice	4.015***	1.897*
	(0.761)	(1.112)
Constrained choice in company stocks	-3.070	−5.30**
	(2.048)	(2.279)
Investment choice ×	0.206	7.181*
constrained choice	(2.105)	(3.367)
Years in DC plans	0.038	0.178
	(0.055)	(0.179)
Married	−2.311*	0.094
	(1.355)	(1.188)
Age	0.224***	-0.017
	(0.082)	(0.111)
Highest education	0.271*	-0.328
	(0.145)	(0.215)
White	-0.502	2.760**
	(1.850)	(0.991)
Annually income ($1000)	0.035*	0.048
	(0.020)	(0.054)
Net worth ($1000)	0.004	0.000
	(0.003)	(0.001)
Employer contribution rate	0.084*	0.059
	(0.046)	(0.054)
Has a DB plan	-1.400	-0.489
	(0.845)	(1.203)
Has an IRA	-23.975	−7.947**
	(20.379)	(1.220)
Industry, occupation,and firm size dummies	Yes	Yes
Constant	-9.996	8.075
	(4.907)	(7.115)
No. of Observations	253	220
Adjusted R^2	0.2179	0.1191

Significance level: *** 1%; ** 5%; * 10%. Robust Standard Error in parenthesis.

that DB plans or IRA is a substitute retirement saving plan of DC plans especially for low-income employees.

In the regression by each compensation level, the effects of gender on contribution rates are also different. The contributions of women are 2 percent higher than men's in the lower income subsample, but the effect of female are not significant in other subsamples. One explanation for the gender difference is that women are residual income earners in their families: many more low-compensation women than men are married to working spouses, and women earn less than men among the majority of working couples. If the contribution decision reflects the family's needs, as opposed to just the employees', then low-income women will contribute as if they had higher incomes than their recorded compensation. This observation may explain the gender gap at the low end of the pay scale, although here the inclusion of the net worth variable should control for the "family" effect. Moreover, that women at the higher income levels behave similarly to men of similar income can also confirm the above explanation.

Another thing needs to be mentioned is the effect of employer contribution rate across different income groups. The presence of such a match increases contribution rates at all compensation levels, and such inducement is stronger the lower the compensation. In fact, for low income participants, a 50% more employer contribution would increase the contribution rates by 7%, and the effect is only 2% for higher income respondents.

3.5.3 Results for Two-Part Regression

Participants' involvement in the DC plans has several levels, such as whether to contribute the first dollar, and how much contribution to make after that. It may be that the ability to direct one's investments encourages participants' positive contribution, but that budget constraints determine in larger part the amount contributed. So I split the contribution decision into two parts: the decision to make a positive contribution, and, conditional on making a positive contribution, the percentage of income contributed.

Section 4 states the formulation of this two-part regression corrected by Heckman selection. The coefficient of the inverse Mills ratio (λ) show positive selection bias for contribution rates in DC plan. Thus the observed saving rate among participants with positive contributions is higher than the population mean would have been observed for

Table 3-4: Linear Models of Participant's Contribution Level by Income Percentile

	Lower income group (less than 25%)	Middle income group (25%–75%)	Higher income group (greater than 75%)
Investment choice	3.192***	2.756**	2.915***
	(1.088)	(1.034)	(0.978)
Constrained choice	−4.639**	-2.231	-2.911
in company stocks	(1.905)	(2.464)	(2.122)
Investment choice ×	7.044	0.018	4.248
constrained choice	(4.349)	(2.811)	(2.557)
Years in DC plans	0.253	0.072	0.022
	(0.258)	(0.114)	(0.079)
Female	2.097	-0.005	-0.846
	(1.003)	(1.041)	(1.838)
Married	-0.394	-1.453	-2.440
	(1.444)	(1.656)	(1.613)
Age	−0.143*	0.164	-0.023
	(0.104)	(0.144)	(0.102)
Highest education	-0.059	0.074	0.642**
	(0.198)	(0.195)	(0.320)
White	0.358	1.093**	1.650
	(1.205)	(1.716)	(1.491)
Annually income	0.318	0.264**	0.018
($1000)	(0.189)	(0.117)	(0.013)
Net worth	0.003	0.011***	-0.001
($1000)	(0.004)	(0.004)	(0.001)
Employer	0.139	0.085	0.045
contribution rate	(0.085)	(0.051)	(0.060)
Has a DB plan	−2.437*	-0.239	-0.431
	(1.371)	(1.097)	(1.175)
Has an IRA	−10.390***	−9.013*	-5.281
	(2.587)	(0.988)	(5.163)
Industry, occupation,and firm size dummies	Yes	Yes	Yes
Constant	13.721	-0.138	-3.425
	(6.360)	(9.896)	(5.505)
No. of Observations	114	239	120
Adjusted R^2	0.2736	0.2020	0.2053

Significance level: *** 1%; ** 5%; * 10%. Robust Standard Error in parenthesis.

the average member of the sample within DC plans had he chosen to contribute positive amount. One explanation would be respondents who enter larger firms or some specific occupation, such as managers, are those who are more likely to save for retirement.[11]

Column one of Table 3-5 reports estimates of a probability model of decision to contribute a non-zero amount, while column two presents estimates of the effect of investment choice given that the individual is making a positive contribution. Assets choice has the largest economic effect and indicates a 25 percent increase (marginal effect) in the probability that participants make a contribution (P-value of 0.000), while the constrained choice significantly decreases the probability of making a positive contribution by 45.4 percent (P-value is 0.000 too). The coefficient of investment choice is still positive and significant even conditional on positive contribution. Whereas, the effect of company stock constraint fades away (becomes insignificant).

This finding rejects the hypothesis that investment choice encourage the participants to contribute in a retirement saving account, but it is the budget constraint, not the self-direction ability, that determines in large part the employees' saving levels in the DC plans after they contribute the first dollar. Investment choice not only encourages the first dollar contribution from employees in the retirement account, but also boosts the amount they decide to save. In contrast, the inclusion of company stock as an investment constraint threaten most employees completely out of the retirement account (zero contribution), and they choose to seek other types of vehicles for retirement savings, such as DB plans and IRA.

In contrast to asset choice variables, employer's contribution rate has no significant effect on the probability of the non-zero contribution rates, but it plays a significant role in the employee contribution rates conditional on positive contribution. The result shows that, conditional on their non-zero contribution, participants will contribution about 20 percent more if they have 100% increase in the employer contribution. This finding is consistent with the result of Engelhardt and Kumar (2006), who use non-linear budget constraint methods to estimate how much employees contribute to the 401(k) plan. That methodology explicitly incorporates both the match rate and the match threshold in the employees' optimization problem.

[11] A full table of coefficients of occupation and firm size dummies are available upon request.

Table 3-5: Two-part Decision:(1)Probability model of decision to contribute;(2) Participant's contribution rates in a DC plan conditional on positive amount

	Positive contribution		Contribution Rates (contribution>0)
	Coef (s.d.)	Marginal Effect	Coef (s.d.)
Investment choice	0.971***	0.252	5.466***
	(0.168)		(2.014)
Constrained choice	−1.333***	-0.454	-1.393
in company stocks	(0.282)		(2.317)
Investment choice ×	0.672**	0.313	6.476
constrained choice	(0.374)		(4.850)
Years in DC plans	-0.025	-0.007	0.144
	(0.010)		(0.118)
Female	0.220	0.057	0.647
	(0.168)		(1.263)
Married	0.016	0.009	-1.236
	(0.195)		(0.934)
Age	0.028*	0.007	0.018
	(0.016)		(0.115)
Highest education	-0.032	-0.006	0.165
	(0.030)		(0.201)
White	0.104	0.030	1.770
	(0.216)		(1.369)
Annually income ($1000)	0.000	0.000	0.045**
	(0.004)		(0.022)
Net worth ($1000)	0.000	0.000	0.002
	(0.000)		(0.003)
Employer contribution rate	-.007	-0.002	0.186**
	(.004)		(0.081)
Has a DB plan	−0.634***	-0.183	-0.177
	(0.161)		(2.711)
Has an IRA	−2.858***	-0.813	-13.523
	(0.954)		(19.519)
λ	-	-	9.964*
			(5.694)
Industry, occupation,	No		Yes
and firm size dummies			
Constant	-0.503	0.408	0.424
	(0.986)		(8.893)
No. of Observation	476		350
Adjusted R^2	0.2681		0.1668

Significance level: *** 1%; ** 5%; * 10%.

3.6 Conclusion

This paper analyzes the effect of participant control over assets on the size of the contribution, using the first wave data from Health and Retirement Survey. Since people who reported having investment choice may, wholly or partially, not be able to control the employer contribution in their pension accounts, I construct a constrained choice variable distinguishable from the unconstrained one.

My preferred estimates indicate that participants with investment choice contribute over three percentage points more of their salary into the DC plan than people without choice, and people constrained in their investment contribute about three percentage points less in their retirement saving account. Male and lower income participants are more likely to be affected by the ability to direct individual accounts. Further, the impact of investment choice is more significant in the effort to encourage participants making a positive contribution than its effect on the actual percentage contributed, whereas the factors influencing budget constraint, such as the employer contribution rate, would play an important role in the decision of how much percentage of the salary to contribute into the retirement account.

Choice over assets does seem to increase participant involvement on many levels–in the decision whether or not to save, and in increasing the amount saved. These estimated differences in investment behavior between participants with and without choice indicate economically meaningful differences in ultimate retirement income. Some proposals to privatize Social Security recommend adding an individual account component to benefits. These results suggest that allowing participants a choice of investment options may increase their retirement saving.

There are several extension could be made based on this study. Firstly, participants in a defined contribution plan usually cannot perfectly control how much contribution to make out of the salary, for default and maximum contribution rates restrict their choices. A survey data set with handful plan design characteristics would be good for an empirical study of contribution rates. Secondly, this study provides an econometric effect of the investment choice, but it does not analyze how the choice variable will enter the budget constraint of the participants. An individual optimization model with budget set of plan design factors would be useful to study the effect of pension designs to a further step.

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