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On the effects of tax-deferred saving accounts

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ON THE EFFECTS OF TAX-DEFERRED SAVING ACCOUNTS

by

Anson Tai Yat Ho

An Abstract

Of a thesis submitted in partial fulfillment of the
requirements for the Doctor of Philosophy
degree in Economics in the
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July 2011

Thesis Supervisor: Associate Professor Gustavo J. Ventura

ABSTRACT

In this dissertation, I develop a framework to study the effects of tax-deferred saving accounts on the aggregate economy. I incorporate tax-deferred saving accounts in a theoretical model of household's life-cycle decisions, which is then linked to the real world data by calibration. I study the effects of tax-deferred saving accounts on the aggregate savings and the aggregate output, and further analyze their impacts of different policy changes.

In the first chapter, I present the important features of tax-deferred saving accounts in the U.S. and their institutional changes over time. I highlight the differences between IRA and 401(k) on their contribution limits and household's eligibility. While IRA has a lower contribution limit and is available to all households, 401(k) has a much higher contribution limit but is only accessible by a fraction of households.

In the second chapter, I present an overlapping-generations model to capture the effects of tax-deferred saving accounts in a general equilibrium framework. There are four key aspects to the model: first, households can save in both ordinary saving account and tax-deferred saving account. Second, there is a nonlinear progressive income tax system. Third, households are heterogeneous in their labor productivity and 401(k) eligibility. Fourth, households decide consumption, savings and labor supply endogenously. The model is calibrated to the US economy in 2000, with the distribution of 401(k) eligibility being an endogenous outcome that matches the data reported in Survey of Income and Program Participation (SIPP) in 2001.

In the third chapter, I study the quantitative effects of tax-deferred saving accounts on the aggregate economy and investigate their policy implications. Specifically, I estimate the macroeconomic impacts of eliminating tax-deferred saving accounts from the economy. To highlight the role played by the heterogeneity of 401(k) eligibility, I conduct a quantitative exercise that provide universal 401(k) eligibility to all households. In these experiments, I maintain government revenue neutrality by introducing a new proportional income tax (subsidy) that has the same effects as a upward (downward) shift of all marginal tax rates in the US income tax schedule. Since the institutional settings of tax-deferred saving accounts essentially provide consumption tax treatments on households retirement savings, I further explore the implications of tax-deferred saving accounts for a proportional consumption tax reform. Results from this study indicate that tax-deferred saving accounts have significant impacts on the aggregate economy and demonstrate that these accounts substantially reduce the impacts of a consumption tax reform.

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CERTIFICATE OF APPROVAL

PH.D. THESIS

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To my loving parents, Ho Kee Ying and So Shui Fung

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CHAPTER 1
INTRODUCTION

1.1 Background

Tax-deferred saving accounts (hereafter TDAs) are important instruments for retirement savings, and they are systematically used in many countries. For example, Canada, Germany, Italy, the Netherlands, and the United Kingdom all allow tax-deferred saving accounts with similar institutional settings.[1] In the U.S., TDAs include, broadly defined, Individual Retirement Account (IRA), 401(k) for private-sector employees, 403(b) for nonprofit-sector employees, 457 plan for public-sector employees, and Keogh accounts.

Generally, all types of TDAs have three common features. First, they provide favorable tax treatments on the capital income within these accounts. Assets within TDAs grow tax-free until withdrawal. Second, TDA contributions are tax deductible, and subsequent withdrawals are taxed as ordinary income. Third, there are contribution and withdrawal constraints on assets in TDAs: contributions are restricted to certain legal limits and can only be made in working age. Early withdrawal before legal withdrawal age is subject to penalty payment in addition to the income taxes incurred from assets withdrawal.

TDAs are of particular interest because of their impacts on the nonlinear progressive income tax system. Since savings and capital income in TDAs are exempted from household income taxation until assets are withdrawn for consumption, TDAs indeed provide consumption tax treatment on retirement savings. As the TDA system has become a sizable component in the U.S. economy, the current U.S. income tax system is essentially a hybrid one made up of a progressive income tax part and

[1] See Guiso et al., eds (2001) for details.

a progressive consumption tax part. As a result, the consumption tax treatment on TDA assets mitigates the distortions created by capital income tax and household income tax.

Furthermore, TDAs also offer a way for households to redistribute their taxable income over time. While contributions to TDAs decrease account holders' current period taxable income, subsequently withdrawals of TDA assets will increase their future taxable income. In a nonlinear progressive tax system, it provides significant tax arbitrage opportunities for households. First, it is due to the difference in household income levels before and after retirement. Working-age households receive income from two sources - labor earnings and capital income, and thus, they face higher marginal income tax rates. After retirement, returns on capital become their sole source of income and place them in tax brackets with lower marginal tax rates. Households can contribute to TDA and take advantage of the differences in marginal tax rates. Furthermore, for those households at the margin of the tax brackets, TDA contributions can reduce their taxable income and place them in a tax bracket with lower marginal income tax rate. Thus, TDAs offer households another channel to respond to distortionary tax policies, in addition to labor supply decisions in a conventional framework. Apart from the tax-preferred treatment on capital income in TDAs, these institutional settings of TDAs induce households to incorporate tax avoidance incentives into their decisions.

The purpose of this study is to investigate the quantitative impacts of TDAs in a general equilibrium framework. Since the purpose of TDAs is to encourage private savings, this study first addresses the effects of TDAs on this aspect. Incremental savings is measured by the differences in the steady state capital levels between the benchmark economy with TDAs and an economy without TDAs. Then, this stduy evaluates the impacts of granting 401(k) access to all working-age households, *i.e.* universal 401(k) eligibility. This experiment analyzes the effects of expanding the

TDA system and removing heterogeneity in 401(k) eligibility. By expanding the consumption tax component, the provision of universal 401(k) eligibility is a way to move towards consumption taxation with minimal changes to the existing tax system. After that, this study proceeds to address the implications of TDAs for a flat tax reform. Since the impacts of a tax reform depends on the conditions of the initial economy, these effects are potentially overstated when TDAs are not taken into account.

The contribution of this study is multifold. The model in this study captures multiple aspects of the current TDA system and provides a better understanding on the effects of TDAs on the aggregate economy. It also sheds light on how household life-cycle decisions are influenced by TDAs and their 401(k) eligibility. Moreover, this study illustrates that TDAs have important implications for a flat tax reform, suggesting that omitting TDAs, or tax avoidance technologies in general, in the assessment of tax policies can be misleading.

1.2 Related Literature on Tax-deferred Saving Accounts

This study is related to three different strands of research in the tax literature, which can be broadly categorized into tax avoidance, the effects of TDAs on savings, and consumption tax reform.

There are vast evidences that high income households respond to the incentives of minimizing tax liabilities. Feldstein (1995) estimates the sensitivity of taxable income to changes in tax rates by comparing the tax returns of taxpayers before and after the 1986 Tax Reform. He finds that the elasticity of taxable income with respect to marginal tax rate is at least one. A complementary study by Auerbach and Slemrod (1997) focusing on the same tax reform conclude that there was a hierarchy of responses, with the most responsive decisions being activities that primarily affect reported income, while the least responsive ones being the real decisions of households and firms. These results provide support to the tax avoidance literature that the response of taxable income involves more than merely a change in the traditional measures of labor supply. Joulfaian and Richardson (2001) use household panel data to study the characteristics of households participating in TDA plans. They find that higher labor earnings and marginal tax rates increase the probability of TDA participation. It provides evidence that households do exploit the tax arbitrage opportunities offered by TDAs. And yet, the tax-based incentive of TDA has not been fully explored.

A lot of effort has been spent on evaluating the effectiveness of TDAs in creating new savings. Since some of the assets in TDAs are shifted from other accounts, which would have been saved anyway, only a fraction of TDA assets represent new savings. To measure the amount of new savings, an intuitive way is to look at the differences in asset levels between households with and without TDAs. However, households saving decisions are also influenced by other factors such as their demographic characteristics and income levels. Empirical estimates on the incremental savings have been done by using different sources of data and different methods for controlling household heterogeneity.[2] The results in these empirical studies are inconsistent with each other, and are sensitive to the method used. For example, Gale and Scholz (1994) uses the data from the Survey of Consumer Finance to estimate the effects of IRA on savings. They control household heterogeneity through a structural approach and find that IRA has little effects on new savings. However, Poterba et al. (1995) control heterogeneity by grouping them in eligibility categories and study the change in asset levels within these groups. They find little evidence that 401(k) contributions substitute for other forms of personal saving. In the absence of a completely randomized control experiment, none of these empirical methods can perfectly isolate the effects of TDA from other factors. Furthermore,

[2] See Poterba et al. (1996), Engen et al. (1996), and Bernheim (2002) for a review of the empirical methods used to estimate TDA induced incremental savings.

these empirical studies are not able to identify the saving incentives induced by tax arbitrage with the preferential tax treatment of capital returns.

In a general equilibrium framework, Imrohoroglu et al. (1998) use an OLG model to evaluate the effectiveness of TDAs on increasing aggregate capital, and they found that the incremental saving lies at the lower end of the range of estimates in the empirical literature. Gomes et al. (2009) consider a more complex asset portfolio structure - direct and indirect stockholders - and find that TDA only marginally increase net savings. These studies assume a proportional tax system and inelastic labor supply, in which the sole motivation for households to save through their TDAs is the favorable tax treatment on capital returns.[3] Thus, they have left out the effects of tax arbitrage opportunities offered by TDAs in a nonlinear tax system. Kitao (2010) extends the analysis by endogenizing household labor supply decisions and incorporating a progressive income tax system into the model, and she finds that TDA has a strong impact on raising capital and output of the economy. Nishiyama (2010) addresses that how the government finances the budgetary cost of transition after TDA is introduced is important in measuring the welfare gain from TDA. A common assumption among studies in theoretical framework is that households are homogeneous in their TDA eligibilities. For instance, Imrohoroglu et al. (1998) and Kitao (2010) set the TDA contribution limit to be roughly the same as the IRA limit, excluding 401(k) from consideration. In contrast, the contribution limit in Nishiyama (2010) is similar to that of 401(k), implying that all households are 401(k) eligible. However, there is vast evidence that households are heterogeneous in terms of 401(k) eligibility.[4]

The model in this study is closest to that in Imrohoroglu et al. (1998) and

[3]The idiosyncratic income shocks in Imrohoroglu et al. (1998) are formulated as i.i.d. unemployment shocks. Gomes et al. (2009) model the income shocks as an AR(1) process.

[4]See section 1.3 for a detailed description about TDAs in the U.S.

Kitao (2010), but it differs in two major ways. It incorporates a nonlinear tax system and hence the tax arbitrage opportunities associated with TDAs. Endogenous labor supply and the more complex labor efficiency process in this model generates heterogeneity in labor earnings similar to the U.S. data, that allows the model to explore the effects of TDAs on the aggregate economy. Furthermore, this model captures the heterogeneity of 401(k) eligibility among households. This is a critical factor in analyzing the impacts of TDA because it limits the extent to which TDAs are used by households. If 401(k) is excluded from the TDA system, the IRA contribution limit becomes an effective constraint on the amount of contributions that agents can make. As result, contributions are likely to be shifted from other sources of savings which would have been done anyway. Thus, the effects of TDA is limited and increasing the TDA contribution limit will have significant impacts on the economy. On the contrary, assuming that all households have access to 401(k) as in Imrohoroglu et al. (1998) and Kitao (2010), most agents are unrestricted by the contribution limit. The impacts of introducing TDA to the economy will be more significant. Since a further increase in the contribution limit will only affect the small fraction of agents who contribute the maximum amount, the effects of relaxing an already generous TDA contribution limit is less significant. Also, the model in this study is more carefully calibrated, taking certain nature of household assets into account.

There is vast research on tax reforms. Notable ones are Auerbach (1997), Ventura (1999), and Altig et al. (2001). These studies have taken the progressive tax system at its face value. However, studies on the relationship between tax avoidance and flat tax reform are scarce. As evidences in tax elasticity show that households can minimize their tax liabilities by adjusting their taxable income through various ways in addition to changing their labor supply, studying the impacts of tax policies by only considering the de jure tax rates can be misleading. Given that TDA is widely available and commonly used, studying the impacts of TDA on a flat tax reform shed some light on the importance.

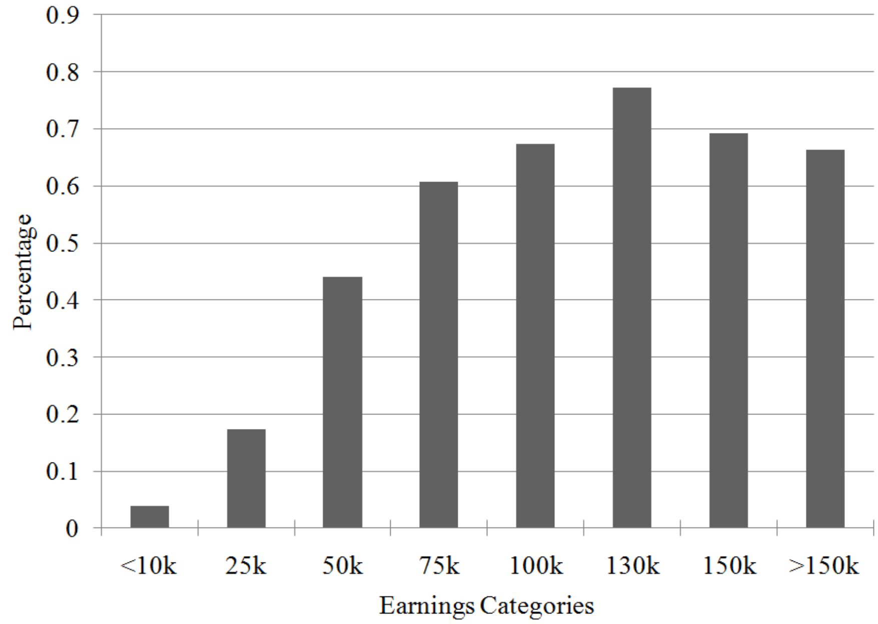
1.3 Features of IRA and 401(k)

Tax-deferred saving accounts in the US has gone through a number of changes since they were introduced. IRA was created in 1974 with the aim of increasing people readiness for retirement. Eligible individuals can and are responsible for setting up their own IRAs with a variety of organizations. Initially, IRAs were limited to workers without a qualified employer retirement plan. The contribution limit was $1,500 from 1975 to 1981. After the Economic Recovery Tax Act of 81 (ERTA '81) was passed, all individuals who are below 70.5 years old and receive compensation from work during the year can set up and contribute their pre-tax income to IRA. [5] The contribution limit was increased to $2,000 from 1982-2001. The Internal Revenue Service (IRS) further increased the contribution limit to $3,000 in 2002, then $4,000 in 2005, and $5,000 in 2008.

As suggested by its name, 401(k) retirement plans were created according to section 401(k) of the Internal Revenue Code in 1978. 401(k) plans are offered by employers and allow a covered employee to have a portion of compensation contributed to her 401(k) plan as a pre-tax reduction in salary. To avoid 401(k) being an unfair instrument leaning towards to rich, the Tax Reform Act of 1984 (TRA '84) introduced employers to "nondiscriminating" rules to ensure that 401(k) does not discriminate in favor of highly compensated employees. The Tax Reform Act of 1986 (TRA '86) further tightened the nondiscrimination rules and substantially reduced the 401(k) contribution limit. Figure 1.1 shows the fraction of workers participated in 401(k) conditional on their labor earnings. While all households have access to IRA, only 50% of total workers are eligible and have participated in 401(k).

[5] Publication 590 (2009), Individual Retirement Arrangements (IRAs). http://www.irs.gov/publications/p590/index.html

Figure 1.1: 401(k) participation conditional on labor earnings in 2001



It imposes substantial heterogeneity in TDA eligibility and hence tax uncertainty. Note that 401(k) eligibility is positively correlated to labor earnings. In 2000, the 401(k) contribution limit was $10,500 per worker or 25% of annual salary, whichever is less. In 2002, the contribution limit is increased to 100% of labor earnings.

While the IRA contribution limit remained about ten percent of average income, 401(k) contribution limit was about 50 percent average income. The much higher contribution limit of 401(k) implies that taking it into account is very important. According to the data from Survey of Consumer Finance (SCF), the amount of assets in TDAs is about 4 trillion dollars, which is roughly equals to 3.5 percent of the US GPD in 2010.

CHAPTER 2
OVERLAPPING-GENERATIONS MODEL

2.1 Introduction

In this chapter, I construct an overlapping-generations model to capture the characteristics of TDAs presented in chapter 1. I begin by specifying the model framework and the definition of a stationary equilibrium in this model. Next, I explain the calibration strategy and the target values used to match the model economy to the U.S. economy in 2000. Then, I conclude this chapter by discussing the performance of the model.

2.2 Model Setup

This chapter used an overlapping generation (OLG) model that incorporates several important household features. First, agents are heterogeneous in their labor efficiencies, which evolve stochastically over time. Second, agents' labor supply decisions are endogenous. Third, there is a risk-free asset that can be saved in two types of accounts: tax-deferred account (TDA) and ordinary asset holdings (OAH). The novel feature of this model is that agents are heterogeneous in their 401(k) eligibility. While all agents are eligible for IRA, only a fraction of agents are eligible for 401(k). Household's 401(k) eligibility status depends on their labor efficiencies and are calibrated to match an endogenous distribution of 401(k) eligibility conditional on labor earnings. Agent's income is subject to non-linear income tax. The existence of TDA and endogenous labor supply allows agents to conduct tax arbitrage, and the stochastic TDA contribution limit controls the extent to which it can be done.

2.2.1 Agents

A large number of age one agents are born in each period, and the population grows at a constant rate of g. Agents live a maximum of T periods and they face mandatory retirement after living R periods. There is an exogenous survival probability, γ_j, that an agent of age j, with $1 <= j <= T$, will survive to age $j+1$. Let μ_j be the fraction of population at age j, then $\mu_{j+1} = \frac{\gamma_j}{(1+g)}\mu_j$ and $\sum\limits_{j=1}^{T} \mu_j = 1$.

Agents are endowed with one unit of time every period. For an agent of working age j at time t, she allocates her time to work $(l_{j,t})$ and leisure $(1 - l_{j,t})$.[1] After mandatory retirement in period $R+1$, she allocates all of her time to leisure, *i.e.* $l_{j,t} = 0$ for $j = R+1 \ldots T$. Thus, an agent's time constraint is expressed as

$$l_{j,t} \begin{cases} \in [0,1] & \text{if } j \leq R \\ = 0 & \text{if } j \geq R+1 \end{cases} . \tag{2.1}$$

She also decides the amount of consumption $(c_{j,t})$. Her preferences is defined by

$$E_0 \left[\sum_{j=1}^{T} \beta^{j-1} u\left(c_{j,t}, l_{j,t}\right) \right] \tag{2.2}$$

where $u\left(c, l\right) = \frac{\left[c^{\theta}(1-l)^{1-\theta}\right]^{1-\sigma}}{1-\sigma}$, $\sigma > 0$, and $\theta \in (0, 1)$.

2.2.2 Endowments

Labor efficiency of an agent consists of two components: an age-specific deterministic efficiency $(\overline{z_j})$ and an uninsurable idiosyncratic labor efficiency shock (z_t). The labor efficiency of an age j agent receiving an idiosyncratic shock z_j is specified as

$$e\left(z_j, j\right) = \exp\left(\overline{z_j} + z_j\right). \tag{2.3}$$

The labor efficiency shocks are idiosyncratic and they follow the AR(1) process

$$z_j = \rho z_{j-1} + \epsilon_j, \;\; \epsilon_j \sim N\left(o, \sigma_z^2\right) \tag{2.4}$$

[1]For the rest of the study, the first subscript denotes the age of the agent and the second subscript denotes the time period. The time subscript will be dropped later as the study focuses on the stationary equilibrium.

and

$$z_1 \sim N\left(0, \sigma_1^2\right) \tag{2.5}$$

where ϵ_j is a random shock at time t drawn from a normal distribution with variance σ_z^2. The initial shock, z_1, is drawn from a normal distribution with variance σ_1^2. Thus, agents supply labor hours $l_{j,t}$ at the effective wage rate w_t to earn $w_t e\left(z_t, j\right) l_{j,t}$.

2.2.3 Assets

Agents are born with no assets and they can hold a risk-free asset in two different accounts: ordinary asset holdings (hereafter OAH) and TDA.[2] Assets in OAH and TDA are identical as a factor of production. Thus, they receive a common rate of return on capital r_t and are subject to a proportional capital income tax with rate τ_k. This capital income tax is used to mimic the corporate profit tax paid by firms. Both OAH and TDA are also subject to zero borrowing constraints

$$s_{j,t}, a_{j,t} \geq 0 \ \forall j, t \tag{2.6}$$

where $s_{j,t}$ and $a_{j,t}$ denotes the assets in OAH and TDA respectively. OAH is not subject to any contribution or withdrawal constraints.

In contrast, TDA is subject to contribution and withdrawal constraints. Contributions to TDA, denoted by $q_{j,t}$, can only be made in agents' working age, *i.e.* $q_{j,t} \geq 0$ for $j = 1 \ldots R$, and assets in TDA can only be withdrawn after retirement, *i.e.* $q_{j,t} \leq 0$ for $j = R+1 \ldots T$. To capture the fact that only a fraction of agents are eligible for 401(k), a stochastic TDA contribution limit, $\bar{q}_t \in \{\bar{q}_L, \bar{q}_H\}$ with $\bar{q}_L < \bar{q}_H$, is imposed on working-age agents. This stochastic TDA contribution limit reflects an agent's 401(k) eligibility. As all agents have access to IRA in the U.S., $\bar{q}_L$ reflects the statutory contribution limit of IRA. Since the differences between IRA

[2] In reality, taxation on capital income is incomplete. For example, returns on municiple bonds are exempted from federal and state income tax. The optimal asset *location* problem has been studied extensively in the finance literature (e.g., Amromin, 2003; Dammon et al., 2004; Shoven and Sialm, 2004; Huang, 2008). This study focuses on the tax arbitrage opportunities associated with the optimal asset *allocation* problem, and hence maintains a single asset environment for simplicity purpose.

and 401(k) are the eligibility status and the contribution limits, these accounts are viewed as substitutes. Having access to 401(k) is equivalent to having a high TDA contribution limit, *i.e.* $\bar{q}_H$ is the sum of the statutory contribution limits of IRA and 401(k).

Since the model will be calibrated to the US economoy in 2000 (see section 4), the maximum 401(k) contribution is further limited to 25% of labor earnings. For an age j agent who is eligible for making 401(k) contribution, her TDA contribution limit is restricted to be 25% of her labor earnings plus the IRA limit or the sum of the IRA and 401(k) statutory limit, whichever is lower. An agent's TDA contribution constraint can be written as

$$q_{j,t} \begin{cases} \in \left[0, \min\left(0.25 w_t e\left(z_t, j\right) l_{j,t} + \bar{q}_L, \bar{q}_H\right)\right] & \text{if } j \leq R \text{ and } \bar{q}_t = \bar{q}_H \\ \in \left[0, \bar{q}_L\right] & \text{if } j \leq R \text{ and } \bar{q}_t = \bar{q}_L \\ \leq 0 & \text{if } j \geq R+1 \end{cases} . \tag{2.7}$$

The stochastic process of $\bar{q}_t$ follows a Markov transition matrix conditional on the agent's labor efficiency with $\Pr\left(\bar{q}_{t+1} = \bar{q}_H | \bar{q}_t = \bar{q}_H, e\left(z_t, j\right)\right) = \eta_H\left(e\left(z_t, j\right)\right)$ and $\Pr\left(\bar{q}_{t+1} = \bar{q}_L | \bar{q}_t = \bar{q}_L, e\left(z_t, j\right)\right) = \eta_L\left(e\left(z_t, j\right)\right)$.[3] For all newborn agents, $\Pr\left(\bar{q}_t = \bar{q}_H\right) = \eta_1\left(e\left(z_1, 1\right)\right)$ and $\Pr\left(\bar{q}_t = \bar{q}_L\right) = 1 - \eta_1\left(e\left(z_1, 1\right)\right)$. The functional form and parameter values of $\eta_L(\bullet)$, $\eta_H(\bullet)$, and $\eta_1(\bullet)$ will further be explained in the calibration section. The total amount of assets in the TDA, denoted by $a_{j,t}$, grows as

$$a_{j+1,t+1} = \left[1 + \left(1 - \tau_k\right) r_t\right] a_{j,t} + q_{j,t}. \tag{2.8}$$

[3] The target of these stochastic 401(k) eligibility processes is to capture the positive correlation between labor earnings and 401(k) eligibility demonstrated in figure 1.1. This study assumes that, from the macroeconomic point of view, the labor market is perfectly competitive and firms randomly offer 401(k) to their employees. Since labor efficiency is positively correlated to labor earnings, conditioning 401(k) eligibility on labor efficiency is a reasonable way to deliver the pattern of 401(k) eligibility in the data. An alternative way is to condition the probability on efficient labor supply $e\left(z_t, j\right) l_{j,t}$. In this sense, labor supply becomes an intertemporal decision because it also affects agent's probability of being 401(k) eligible next period. Given that 401(k) is randomly offered by employers, the former specification in which agents have no control on the 401(k) probability is a more sensible one. There is also a practical consideration in using the former specification. If the probability of 401(k) eligibility depends on labor earnings, then labor supply is no longer an intratemporal decision because it also affects agent's probability of being 401(k) eligible *next period*. It makes the computation of decision rules substantially more difficult.

2.2.4 Taxes

After agents make their contributions to TDAs, the remaining of their income (labor earnings plus the returns on OAH minus TDA contribution) is taxed according to a piecewise linear progressive tax function $T(\bullet)$. The marginal tax rates are conditional on the gross income of the agents. Let $I = \{I_1, I_2, I_3, I_4, I_5\}$ be the cutoff points of the tax brackets. For an agent with income $w_t e(z_t, j) l_{j,t} + r_t s_{j,t} - q_{j,t} \in (I_4, I_5]$, her tax liability is

$$\begin{aligned} T(w_t e(z_t, j) l_t, r_t s_t, q_{j,t}) &= \tau_1 (I_2 - I_1) + \tau_2 (I_3 - I_2) + \tau_3 (I_4 - I_3) \\ &\quad + \tau_4 ([w_t e(z_t, j) l_{j,t} + r_t s_{j,t} - q_{j,t}] - I_4) + \tau_k \cdot r_t s_{j,t}. \end{aligned} \tag{2.9}$$

The important difference between OAH and TDA is that the returns of assets in TDA are *not* included in agents' taxable income.

In addition to the income tax, agents also pay social security taxes on their labor income at rate τ_{ss}. All retired agents receive an equal amount of social security benefits $b_{j,t}$, where $b_{j,t} = 0$ for $j \leq R$. Accidental bequest (TR_t) is distributed evenly across agents as lump sum transfers. The budget constraint for an agent of age j at time t is

$$c_{j,t} + s_{j+1,t+1} + q_{j,t} \begin{cases} = (1 - \tau_{ss}) w_t e(z_j, j) l_{j,t} + (1 + r_t) s_{j,t} & \text{if } j \leq R \\ \quad -T(w_t e(z_j, j) l_{j,t}, r_t s_{j,t}, q_{j,t}) + TR_t & \\ = (1 + r_t) s_{j,t} - T(0, r_t s_{j,t}, q_{j,t}) + b_{j,t} + TR_t & \text{if } j > R \end{cases} \tag{2.10}$$

2.2.5 Individual Problem

The decision problem of a new born agent at time t can be written as

$$\max E_0 \left[\sum_{j=1}^{T} \beta^{j-1} u(c_{j,t}, l_{j,t}) \right]$$

$s.t. \, (2.1), (2.6), (2.7), (2.8), (2.10)$

2.2.6 Firms

Markets are competitive. There is a representative firm using capital (K) and efficient labor (N) as inputs to produce output (Y) through a Cobb-Douglas production technology

$$Y_t = K_t^{\alpha} N_t^{1-\alpha} \tag{2.11}$$

The firm's profit maximization problem is

$$\max_{K_t, L_t} Y_t - (r_t + \delta) K_t - w_t N_t \tag{2.12}$$

where δ is the depreciation rate, and r_t and w_t are the rate of return on capital and the efficient wage rate respectively. The first order conditions of the firm profit maximization problem implies

$$r_t = \alpha K_t^{\alpha-1} N_t^{1-\alpha} - \delta \tag{2.13}$$

and

$$w_t = (1-\alpha) K_t^{\alpha} N_t^{-\alpha}. \tag{2.14}$$

2.2.7 Recursive Formulation

As this study focuses on the economy with a stationary equilibrium, the time subscript is dropped whenever possible to maintain simplicity. In this model, agents are heterogeneous in their asset levels in OAH, TDA, TDA contribution limit, and the realization of their idiosyncratic labor efficiency shocks. The state of an agent can be summarized by $x = (s, a, \bar{q}, z)$, $x \in X$, where $X = \mathbb{R}^+ \times \mathbb{R}^+ \times \{\bar{q}_H, \bar{q}_L\} \times \mathbb{R}$. The agent's problem can be written recursively in the dynamic programming language

$$V(x, j) = \max_{c, l, s', q} u(c, l) + \beta E[V(x', j+1)]$$

s.t.

$$c + s' + q = \begin{cases} (1-\tau_{ss}) we(z, j) l + (1+r) s - T(we(z, j) l, rs, q) + TR & \text{if } j \leq R \\ (1+r) s - T(0, rs, q) + b + TR & \text{if } j > R \end{cases}$$

$$l\begin{cases}\in[0,1] & \text{if } j\leq R\\ =0 & \text{if } j\geq R+1\end{cases}$$

$$q\begin{cases}\in\left[0,\min\left(0.25we\left(z,j\right)l+\bar{q}_L,\bar{q}_H\right)\right] & \text{if } j\leq R \text{ and } \bar{q}=\bar{q}_H\\ \in\left[0,\bar{q}_L\right] & \text{if } j\leq R \text{ and } \bar{q}=\bar{q}_L\\ \leq 0 & \text{if } j\geq R+1\end{cases}$$

$$a',s'\geq 0$$

$$a'=\left[1+\left(1-\tau_k\right)r\right]a+q$$

In order to specify the model equilibrium, a probability measure φ_j defined on subsets of individual state space (X) is used to describe the heterogeneity among agents of age j. Let the probability space be $(X,B(X),\varphi)$, where $B(X)$ is the Borel σ-algebra on X. The probability measure must be consistent with the individual decision rules of OAH $s(x,j)$ and TDA contribution $q(x,j)$, and the law of motion of the TDA contribution limit $\bar{q}$ and the efficiency shock z. The distribution of individual states across age 1 agents is determined by the joint initial distribution of TDA contribution limit and labor efficiency shock. For agent of age $j>1$, the probability measure is given by the recursion

$$\varphi_{j+1}\left(B\right)=\int_X \Pr\left(x,j,B\right)d\varphi_j, \tag{2.15}$$

where

$$\Pr\left(x,j,B\right)=\sum_{i\in\{H,L\}}\Pr\left(\bar{q}',\bar{q}_i\right)\int\Pr\left(z',z\right)dz$$
$$\text{if } \left(s\left(x,j\right),\left[1+\left(1-\tau_k\right)r\right]a+q\left(x,j\right),\bar{q}',z'\right)\in B.$$

Otherwise, $\Pr\left(x,j,B\right)=0$.

Definition 2.2.1 *A stationary equilibrium in this model is a set of decision rules $c(x,j),s(x,j),q(x,j)$ and $l(x,j)$, factor prices r and w, taxes paid $T\left(we\left(z,j\right)l\left(x,j\right),rs\left(x,j\right),q\left(x,j\right)\right)$, lump sum transfer of accidental bequests TR, social security b, aggregate capital K, aggregate efficient labor L, government consumption G, a social security tax τ_{ss}, a tax regime, and distributions of agents $\{\varphi_j\}_{j=1}^T$ such that*

1. $c(x,j)$, $s(x,j)$, $q(x,j)$ and $l(x,j)$ are the optimal decision rules on consumption, next period OAH, TDA contribution, and labor supply respectively.

2. factor prices are determined competitively, *i.e.* $w = (1-\alpha) K^{\alpha} N^{-\alpha}$ and $r = \alpha K^{\alpha-1} N^{1-\alpha} - \delta$.

3. Markets clear

   (a) Capital market clears
   $$(1+g) K = \sum_{j=1}^{T} \mu_j \int_X a(x,j) + s(x,j)\, d\varphi_j$$

   (b) Labor market clears
   $$L = \sum_{j=1}^{T} \mu_j \int_X l(x,j)\, e(z,j)\, d\varphi_j$$

   (c) Goods market clears
   $$C = \sum_{j=1}^{T} \mu_j \int_X c(x,j)\, d\varphi_j$$
   $$Y = C + (g+\delta) K + G$$

4. Government maintains budget balance
$$G = \sum_{j=1}^{T} \mu_j \int_X T\left(we(z,j)\, l(x,j), rs_j, q_j\right) d\varphi_j$$

5. Social security expenditure is equal to the social security tax receipt
$$\tau_{ss} w L = \sum_{j=R+1}^{T} \mu_j b$$

6. Accidental bequest is equal to transfers
$$TR = \sum_{j=1}^{T} (1-\gamma_j)\, \mu_j \int_X (1+r)\left[a(x,j) + s(x,j)\right] d\varphi_j$$

7. Distributions are consistent with individual behavior as stated in (2.15).

2.3 Calibration

The model is calibrated to the U.S. economy in 2000, with each model period equal to one year. Households enter the economy at age twenty-one, retire at age sixty-one, and live at most to one hundred years old. Thus, households live a maximum of eighty periods and retire after forty periods. The age conditional survival rate is based on the mortality data from the US Census Bureau in 2000, with the conditional survival rate from age one hundred to one hundred and one arbitrarily set to zero. The population growth rate is 0.01, matching the long term U.S. population growth from 1950 to 2000.

There are two components in the labor efficiency process to be calibrated. The deterministic path of household's age-earning profile is taken from the age conditional earnings estimates in Hansen (1993), with linear interpolation for age-efficiency points that are not available. The parameters of the labor efficiency shocks are directly taken from the estimates in Heathcote et al. (2008), and the variance of the persistent shock is computed as the average of those year-specific variances from 1991 to 2000 in the same study.

The risk aversion parameter (σ) is 4. The coefficient of the consumption goods (θ) in the utility function is 0.324, such that the equilibrium average labor supply of workers to be 0.33. These parameters imply that the Frisch elasticity of labor supply of an agent supplying mean hours is about one.

The discount factor, capital share of output, and the depreciation rate are calibrated in the same fashion as in Cooley and Prescott (1995). Due to differences in model structure, I applied a different treatment on the estimation of capital. First, owners occupied housing is excluded from the stock of capital. The rationale is as follows: the model explicitly specifies the accounts through which agents can hold assets, but it does not specify the types of assets that can be held in each account. Under the single asset assumption in this model, owners occupied housing is identical to other types of assets. Including owners occupied housing in the notion of capital implies that it can be partially saved in TDA. However, wealth in TDA is mainly composed of financial assets. This creates an inconsistency on the use of TDAs between the model and in reality. In particular, the fraction of assets in TDAs will be higher if owners occupied housing is included.[4] This mismatch is quantitatively important because empirically around thirty percent of household net worth is held in terms of owners occupied housing. For consistency purposes, investment, depreciation, and imputed service flow from owners occupied housing are excluded from relevant calculations. Second, as the government in this model only consumes output and does not invest in capital, government capital is also excluded from the calculation of capital. According to this calibration, the discount rate is 0.953, set to match a capital-output ratio of 1.872 in the model. The capital share of output (α) is 0.334. The depreciation rate is 0.096.

Tax brackets and the marginal tax rates are taken from the U.S. Internal Revenue Services. Tax brackets are expressed as fractions of average household income reported by the US Census Bureau in 2000. For personal exemptions, households are assumed to be married file jointly and take the standard deduction. For the capital income tax rate, I estimated the capital income tax base by the capital share of output in each year. Then the capital income tax rate is calculated as average percentage of the corporate income tax receipts to capital share of GDP (net of depreciation) from 1987 to 2000. Social security tax is calculated as the average percentage of social security payment (OASDI) to the total compensation to employees and the labor share of proprietary income from 1987 to 2000.

2.3.1 TDA Contribution Limits

The TDA contribution limits are calibrated to average household earnings in 2000. I assume that there are two income earners in the household and both of them share the same 401(k) eligibility status. Thus, the IRA and 401(k) contribution

[4] Technically, the empirical capital-output ratio increases when owners occupied housing is included in the notion of capital. To reproduce a higher capital-output ratio in the model, the discount rate (β) has to increase to induce agents to accumulate more assets.

Table 2.1: Income tax schedule and TDA contribution limits

Labor earnings	Avg. income (χ)	Marginal tax rate
$(0, \mathtt{I}_1]$	$0.0\chi - 0.5\chi$	$\cdot$
$(\mathtt{I}_1, \mathtt{I}_2]$	$0.5\chi - 1.268\chi$	$\tau_1 = 0.15$
$(\mathtt{I}_2, \mathtt{I}_3]$	$1.268\chi - 2.354\chi$	$\tau_2 = 0.28$
$(\mathtt{I}_3, \mathtt{I}_4]$	$2.345\chi - 3.326\chi$	$\tau_3 = 0.31$
$(\mathtt{I}_4, \mathtt{I}_5]$	$3.326\chi - 5.547\chi$	$\tau_4 = 0.36$
$> \mathtt{I}_5$	$> 5.547\chi$	$\tau_5 = 0.396$
$\bar{q}_L$	0.07χ	
$\bar{q}_H$	0.438χ	

limits are set to be twice of the per worker limits. The low TDA contribution limit is set to be that of IRA, and the high contribution limit is the sum of the IRA and 401(k) contribution limits. The tax brackets and the TDA contribution limits, expressed as fraction of average household income, are summarized in table 2.1.

Estimating the probability of being eligible of making 401(k) contribution is more complex. In this model, 401(k) eligibility depends on agents' labor efficiency. However, the Survey of Income and Program Participation (SIPP) only reports the percentage of workers participated in 401(k) plans conditional on different categories of labor earnings, which also depends on agents endogenous labor supply decisions. Hence, the conditional probabilities on 401(k) eligibility are calibrated within the model. First, I assume the conditional probability functions $\eta_L(\bullet)$ and $\eta_H(\bullet)$ have logitistic functional forms. Specifically,

$$\eta_i\left(e\left(z_j, j\right)\right) = \frac{1}{1 - \exp(-\pi^i)} \tag{2.16}$$

where $\pi^i = \lambda_0^i + \lambda_1^i \ln\left[e\left(z_j, j\right)\right] + \lambda_2^i \ln\left[e\left(z_j, j\right)\right]^2$ for $i \in \{L, H\}$. With $\eta_L(\bullet)$ and $\eta_H(\bullet)$ specified, the probability of initial 401(k) eligibility, $\eta_1(\bullet)$, is taken from the stationary distribution conditional on labor efficiencies.

Table 2.2: 401(k) participation data in 2001 from SIPP

Earnings Category	401(k) Participation
$< 0.274\chi$	3.9%
$0.274\chi - 0.685\chi$	17.4%
$0.685\chi - 1.369\chi$	44.0%
$1.369\chi - 2.054\chi$	60.7%
$2.054\chi - 2.738\chi$	67.4%
$2.738\chi - 3.560\chi$	77.3%
$3.560\chi - 4.107\chi$	69.2%
$> 4.107\chi$	66.3%

Note: Average household income (χ) is $58,208.4 in 2001.

There are six parameters to be estimated within the model. Given the equilibrium wage rate and the optimal labor supply decisions, I simulated a hundred thousand agents and record their labor earnings and 401(k) eligibility, aiming at reproducing the 2001 participation data reported in the SIPP.[5] Since the SIPP categorizes workers' earnings into eight categories and reports the conditional 401(k) participation rate, two adjustments to the earning categories are done to make the results comparable. First, I transformed the earning categories in the SIPP from worker's earnings to household earnings by assuming that household earnings is 1.7 times of worker's earnings. Second, I expressed the household earnings categories as fractions of average household income. The parameters on 401(k) eligibility are estimated to minimize the sum of squared errors between the data and the simulated results.

[5]As pointed out in Poterba et al. (1995), 401(k) eligibility is not the same as its participation. There are many factors affecting agent's 401(k) participation conditional on eligibility that cannot be captured in the model (e.g., Bayer et al., 2009; Duflo and Saez, 2003; Madrian and Shea, 2001; Papke and Wooldridge, 1996). Calibrating the model to the 401(k) eligibility data in SIPP will deliver a higher participation rate than the data counterpart. Thus, the 401(k) eligibility in the model is calibrated to the participation rate to deliver a closer match with the data.

2.3.2 Summary

Calibration values of the model parameters are summarized in table 2.3. To sum up, labor efficiency parameters (ρ, σ_1^2, and σ_z^2) are borrowed from the empirical estimates documented in Hansen (1993) and Heathcote et al. (2008). Demographic parameters on population growth and survival rates are taken directly from the U.S. data. Production parameters on capital share and depreciation rate are estimated from the NIPA data following the approach in Cooley and Prescott (1995). Income tax rates and tax brackets are taken from the IRS, while the capital tax rate and the social security tax rate are estimated using the data from the Office of Budget and Management. Preference parameters and the parameters for 401(k) eligibility are estimated within the model to deliver the target moments.

2.4 Model Performance

Overall, the benchmark economy provides a good fit to the data. The distribution of 401(k) eligibility produced by the model is consistent with the data. Figure 2.1 shows that the model is able to capture the hump shape characteristics of the conditional 401(k) eligibility. The extent of TDA usage in the model is also consistent with that in the data. Table 3.2 shows the amount of capital held in each account. In the model, the fraction of aggregate capital held in TDAs is about 65.9 percent. Note that owners occupied housing are excluded from the notion of capital in this model. This model implied percentage of capital in TDAs is consistent with the ratio of TDA-to-total financial assets (55.2 percent) calculated by Bergstresser and Poterba (2004) using the data from the Survey of Consumer Finances in 1998.[6]

[6]These numbers should be interpreted with caution. Since the ratio reported in Bergstresser and Poterba (2004) only includes households with *both* TDA and non-TDA assets, it tends to underestimate the fraction of financial assets held in TDAs. On the other hand, the notion of capital in this model is not strictly limited to financial assets. The bottomline is that these ratios

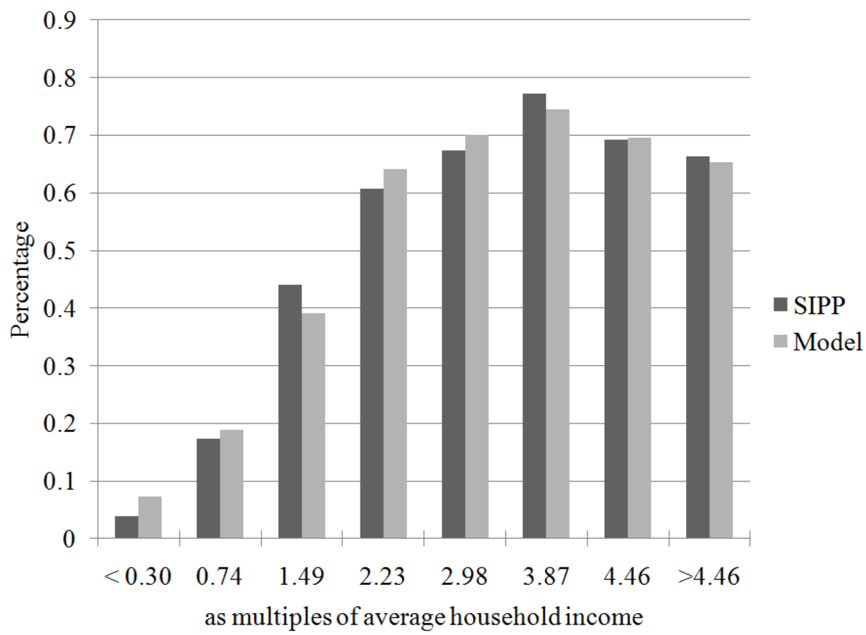
Table 2.3: Parameter values of the calibrated model

Parameters	Name	Value	Target / Data Source
T	max period	80	max age = 100
R	last period of work	40	retire at age 61
β	discount rate	0.9553	capital-output ratio = 1.873
σ	risk aversion parameter	4	
θ	consumption coefficient	0.324	match labor supply = 0.333
g	population growth rate	0.01	Avg. growth 1950-2000
$\{\gamma_j\}$	survival probability		2000 mortality rate from SSA
$\{\bar{z}_j\}$	deterministic ability		Hansen (1993)
ρ	persistence of ability shocks	0.9733	Heathcote et al. (2008)
σ_z^2	variance of the random term	0.0176	Heathcote et al. (2008)
σ_1^2	var of initial distribution	0.1242	Heathcote et al. (2008)
α	capital share of output	0.3342	Avg. capital share 1959-2000
δ	depreciation rate	0.0960	Avg. depreciation 1959-2000
τ_{ss}	social security tax	0.1064	Estimated from OMB data
τ_k	tax on capital income	0.0984	Estimated from OMB data

Table 2.4: Descriptive statistics of the benchmark economy

K/Y	N	Mean hours	Y	r	w	G/Y
1.873	0.370	0.33	0.503	0.082	0.915	0.094

Figure 2.1: 401(k) participation in the model and the 2001 SIPP data



Descriptive statistics of the benchmark economy is reported in Table 2.4. The model also does reasonably well in delivering key aspects regarding the tax system. With TDAs and the U.S. tax system, the ratio of government expenditure to aggregate output in the model is 9.4 percent, which is close to the average of its empirical counterpart from 1987 to 2000 (9.9 percent).[7]

are roughly consistent, which means that the model provides a reasonably well approximation of households use of TDA in the US economy.

[7]In this model, government consumption is equal to its revenue, which is the sum of revenues from income tax and capital tax. Thus, the empirical government consumption is calculated as the sum of tax receipts from individual income taxes and corporate income taxes. Data is obtained from Table 2.1 in the *Budget of the U.S. Government* published by the Office of Management and Budget.

Table 2.5: Decisions of households in different age groups

	21-30 yr	31-40 yr	41-50 yr	51-60 yr
Labor hours per worker				
Benchmark	0.357	0.358	0.323	0.274
401(k) eligible	0.365	0.359	0.324	0.283
401(k) non-eligible	0.353	0.356	0.322	0.267
Without TDA	0.371	0.361	0.315	0.254
Universal 401(k)	0.353	0.354	0.329	0.278
Assets per worker				
Benchmark	0.092	0.568	1.207	1.806
401(k) eligible	0.174	0.722	1.478	2.283
401(k) non-eligible	0.052	0.421	0.932	1.365
Without TDA	0.130	0.708	1.338	1.658
Universal 401(k)	0.079	0.561	1.263	1.970

Note: Benchmark, without 401(k), and universal 401(k) show the average values per worker in the three different scenarios. For the benchmark case, households are further divided into those who are eligible and non-eligible for 401(k). Average values conditional on 401(k) eligibility are reported seperately in rows beneath the benchmark case.

As shown in Table 2.5, eligibility to 401(k) has significant impacts on households' labor supply decisions. 401(k) eligible households supply more labor hours than non-eligible households in all age groups. Since 401(k) eligible households have higher contribution limits, they can utilize their TDAs to a greater extent for tax arbitrage. The differences in labor hours are most significant when households first enter the labor force (21-30 year olds) and are about to retire (51-60 years old).

On household savings, 401(k) eligible households accumulate more assets than non-eligible households in all age groups. The percentage difference in asset holdings

Table 2.6: Distributional statistics of the benchmark economy

	Earnings Gini	Income Gini	Wealth Gini
U.S. data	0.47	0.51	0.83
Model	0.31	0.48	0.63

is largest in the youngest age group, with eligible households saving 3.3 times more than non-eligible households. There are several factors contributing to these results. First, 401(k) eligible households have higher contribution limits that are less likely to be binding. Those eligible households who would *optimally* contribute more than the IRA limit can save more in their TDAs. Second, assets in TDAs grow much faster than that held as OAH because of the favorable tax treatment on capital income in TDAs. Due to the effect of compound growth, the effects of such favorable tax treatment are largest when households are young and lead to the large differences in asset levels in the youngest age group. Third, eligible households are potentially high wage earners because they have higher labor efficiencies on average. As a result, they accumulate more assets than their non-eligible, low efficiencies counterparts.

2.5 Summary and Conclusions

An overlapping generations (OLG) model is employed to study the use of TDA in the U.S. economy. Households are heterogeneous in their labor efficiencies, which also evolve stochastically over time. Each period they decide the amount of time they spend at work and allocate their income on consumption and savings. Households can accumulate assets in their TDAs and/or as their ordinary asset holdings (hereafter OAH). TDAs in this model are subject to contribution and withdrawal constraints and receive tax-free treatment on capital income. Households are also heterogeneous in their 401(k) eligibilities. While all households are eligible for IRA, only a fraction of households are eligible for 401(k). Households' 401(k) eligibilities depend on their labor efficiencies and the pattern is calibrated to match the data in the 2001 Survey of Income and Program Participation (SIPP). After TDA contributions are deducted, household's remaining income is taxed in a progressive tax system. Markets are incomplete and households face uninsurable risks on labor efficiency, mortality, and 401(k) eligibility. These model settings are able to capture key aspects of the TDA system.

CHAPTER 3
EFFECTS OF TAX-DFERRED SAVING ACCOUNTS

3.1 Introduction

In this chapter, I use the calibrated model in chapter 2 to conduct two counterfactual experiments on TDA policies. I consider the elimination of TDAs in section 3.1 and the case of universal 401(k) eligibility in section 3.2. In these experiments, government revenue neutrality is maintained through a new proportional income tax. In section 3.3, I explore the implications of TDAs for a consumption tax reform.

3.2 Effects of TDAs on Private Savings

Since TDAs provide tax incentives for households to save in those accounts, it is important to understand the quantitative impacts of TDA on the aggregate economy. The effects of TDAs on private savings is evaluated by steady-state comparison between the benchmark economy and the economy without TDA, *i.e.* $\bar{q} = 0$. Incremental savings is defined as the percentage increase in aggregate capital when TDAs are allowed in the economy. The tax brackets and the marginal tax rates are kept at the benchmark levels.[1] A new proportional income tax is introduced with a flat tax rate τ_g to maintain government revenue neutrality. It only applies to income above $\mathtt{I}^*$. Hence, the tax function of the economy without TDA is written

[1] Average household income in the benchmark model is used to calculate the tax brackets, so that any changes on average income in this counterfactual experiment does not affect the values of the tax brackets.

as

$$T\left(w_t e\left(z_j, j\right) l_t, r_t s_t\right) = \tau_1\left(\mathtt{I}_2 - \mathtt{I}_1\right) + \tau_2\left(\mathtt{I}_3 - \mathtt{I}_2\right) + \tau_3\left(\mathtt{I}_4 - \mathtt{I}_3\right)$$
$$+ \tau_4\left(\left[w_t e\left(z_j, j\right) l_{j,t} + r_t s_{j,t}\right] - \mathtt{I}_4\right) + \tau_k\left(r_t s_{j,t}\right)$$
$$+ \tau_g\left(\left[w_t e\left(z_j, j\right) l_{j,t} + r_t s_{j,t}\right] - \mathtt{I}^*\right) \quad (3.1)$$

The exemption level of the new tax is chosen to be the same as that in the benchmark model ($\mathtt{I}^* = \mathtt{I}_1$), implying that the government changes the marginal income tax rates of all income brackets by τ_g.[2]

Results on the introduction of TDA are reported in the third column of table 3.1. Aggregate capital, labor supply, mean hours, and output of the benchmark model are normalized to one, and that of the economy without TDA are expressed as fractions relative to the benchmark model. In general, TDA increases the aggregate capital, but have very little effects on labor supply and mean hours. Consequently, the aggregate output level only increases by 1.2 percent.

The aggregate capital stock increases by 3.7 percent. This increase is due to the consumption tax treatment on income contributed to TDAs. First, households can contribute pre-tax income to their TDAs and exploit the tax arbitrage opportunities (difference between current and after-retirement marginal income tax rate). Second, capital income from assets in TDA is free of income tax. It increases the after-tax rate of return on capital and induces households to save more for retirement consumption. On the other hand, an increase in the aggregate capital lowers the rate of return on capital from 8.6 percent to 8.1 percent. This equilibrium price effect counteracts the tax-incentives from TDA. The composition of capital in Table 3.2 shows that there is a strong reallocation of assets from OAH to TDA. The amount of assets in OAH decreases by 64.6 percent when TDA is introduced. Defining new savings from TDA as the increase in capital divided by assets in TDA,

[2]Experiments on $\mathtt{I}^*$ equals to zero and twenty five percent average labor earnings are also conducted. Since those results are very similar (less than 0.5 percent difference) to that of $\mathtt{I}^* = \mathtt{I}_1$, they are not reported in this chapter.

Table 3.1: Model Results with Different TDA Contribution Limits

	Benchmark	Without TDA	Universal 401(k)
K	1.000	0.964	1.047
N	1.000	1.000	1.004
Mean hours	1.000	0.997	1.005
Y	1.000	0.988	1.018
Earnings Gini	0.31	0.32	0.31
Income Gini	0.48	0.42	0.48
Wealth Gini	0.63	0.56	0.63
r	0.081	0.086	0.076
w	0.915	0.904	0.928
τ_g		-3.20%	0.12%

Note: Aggregate capital (K), aggregate efficient labor (N), mean hours, and output (Y) in the benckmark model are normalized to one. Values in the experiments are expressed as fractions relative to their counterparts in the benchmark model. K_{TDA}/K refers to the fraction of aggregate capital held in TDA.

Table 3.2: Composition of Capital

	Benchmark	Without TDA	Universal 401(k)
K	1.000	0.964	1.047
K_{TDA}	1.000	0.000	1.165
K_{OAH}	1.000	2.831	0.822
K_{TDA}/K	0.659	0.000	0.733

Note: K refers to the amount of aggregate capital, which is the sum of assets in TDA and OAH. K_{TDA} is the amount of capital in TDAs. K_{OAH} is the amount of capital held as OAH. K, K_{TDA}, and K_{OAH} in the benckmark model are normalized to one. Values in the experiments are expressed as fractions relative to their counterparts in the benchmark model.

only 5.4 percent of assets in TDA are new savings in the economy.

At the aggregate level, labor supply and mean hours roughly stay the same. On one hand, increase in the capital stock also drives up the wage rate by about 1.2 percent. The price of leisure rises and the substitution effect induces agents to devote more time to work. Furthermore, TDA contributions enable some agents to move to other tax brackets with lower marginal tax rates. On the other hand, the income effect on leisure causes agents to devote more time to leisure. The income, the tax arbitrage incentives, and substitution effects roughly cancel out each other.

In spite of the small effects of TDA at the aggregate level, Table 2.5 shows that TDA has important implications on household decisions in different age groups. In the model without TDA, households in first half of their working lives (age 21-40) supply more labor hours than those in the benchmark model, and the reverse is observed in the later half of their working lives (age 41-60). The direction of these differences is robust to households 401(k) eligibilities. In the benchmark economy, households in the two elder age groups supply more labor hours because of the tax deductibility of TDA contribution. Since households in those two age groups on average are more efficient than younger households, they potentially have higher income and face higher marginal income tax rates. By making TDA contributions, they can reduce their taxable income without decreasing their labor hours. Furthermore, returns on capital also affect households marginal tax rates at different age. As households accumulate more assets for retirement, they receive more capital income. That effectively put them into tax brackets with higher marginal tax rates. In the benchmark economy, however, capital income from assets in TDA represents is tax free and is a large part of households' capital income. In all age groups younger than 50, households in the benchmark economy have lower levels of savings than those in the economy without TDA. It is because of the compound growth of assets in TDA and the income effect induced by the higher after-tax capital rate of return.

The new income tax in the economy without TDA is negative, meaning that the government *reduces* the marginal income tax rates by 3.2 percent to maintain revenue neutrality when TDAs are eliminated. It is because the government collects extra tax revenue without the tax-free treatment on capital return and the tax arbitrage opportunities offered by TDAs. The decrease in marginal income tax rates also have implications on the aggregate effects of TDAs. On aggregate capital, an decrease in income tax rates means that returns on capital in the economy without TDA are subject to lower tax rates, and thus it increases the amount of savings. Also, lower tax rates also encourage agents to increase their labor hours. As a result, the effects of eliminating TDAs are reduced.

3.3 Universal 401(k) Eligibility

This section is devoted to study the quantitative impacts of heterogeneity of 401(k) eligibility. In particular, I explore the effects of giving all households eligibility in making 401(k) contributions. This experiment expands the TDA system in which all agents have a common TDA contribution limit $\bar{q}_H$.[3] Another way to view this reform is that the government imposes heterogeneous IRA limits on households conditional on their 401(k) eligibility, such that all households have a common TDA contribution limit. For agents who do not have access to 401(k), their IRA contribution limits are the sum of the current IRA and 401(k) limit, while the IRA contribution limit for 401(k) eligible agents remains the same. As in the previous section, a new proportional income tax of rate τ_g and exemption level $\mathtt{I}_1$ is introduced to maintain government revenue neutrality.

This TDA experiment serves multiple purposes. First, it sheds light on the impacts of raising the TDA contribution limit. With the current hybrid system of income and consumption taxation, one way to move towards consumption tax is by expanding the TDA system. By increasing the contribution limit, the portion of consumption tax also increases. This policy reform can easily by carried out with minimal changes to the tax system. Second, it also removes the heterogeneity in 401(k) eligibility, which imposes uncertainty on households' TDA contribution limits and hence their future income tax rates. Third, this reform reflects the importance of capturing the characteristics of 401(k) eligibility in the data. It shows how much the impacts of TDA are overestimated when a broad definition of TDA that includes IRA and 401(k) is used without considering the pattern of 401(k) eligibility.

Results are reported in the second column of table 3.1. Overall, removing heterogeneity of 401(k) eligibility has impacts of similar degree to the introduction of TDA. Aggregate capital rises by 4.7 percent. Note that the magnitude of this increase is comparable to the effects of introducing the TDA system in the economy (in Section 6.1). More assets are reallocated from OAH to TDA (Table 3.2). Compared with the benchmark model, the amount of assets in OAH decreases by 17.8

[3] Same as the tax brackets, the contribution limit is set with respect to the average household income in the benchmark model, such that the contribution limit is not affected by the macroeconomic impacts of the TDA reform.

percent and that in TDA increases by 16.5 percent. A large fraction of incremental TDA assets are new savings in the economy, and most of which are attributed to households with high earning potentials. It is because they are the ones who can be benefited the most from making TDA contributions beyond the IRA limit.

Aggregate labor supply and mean hours only increase by 0.4 and 0.5 percent respectively. The capital-output ratio increases with universal eligibility, and consequently the interest rate decreases and the effective wage rate increases. Aggregate output also increases by 1.8 percent. Although providing universal 401(k) eligibility and introducing the TDA system have similar aggregate effects, universal 401(k) eligibility does not have much effects on government revenue. The new proportion tax is only 0.12 percent, meaning that the government only has to increase the income tax rate marginally to balance its budget.

The importance of capturing 401(k) heterogeneity can be illustrated by comparing the economy with universal 401(k) to that without TDA. The impacts of introducing TDA (with universal 401(k) eligibility) almost doubled. For instance, aggregate capital increases by 8.6 percent instead of 3.7 percent in the benchmark analysis. It shows that when a broad notion of TDA, *i.e.* IRA and 401(k), is considered, it is quantitatively important to capture the pattern of 401(k) eligibility in order to have a realistic estimates on the effects of TDA.

The effects of TDA on the household decisions in different age groups (shown in Table 2.5) intensifies as 401(k) becomes universally eligible. The labor supply of households in the 21-30 and 31-40 age groups decreases and the labor supply of households in the 41-50 and 51-60 age groups rises. Since TDA contributions are tax deductible and households are certain that they can use both IRA and 401(k) to accumulate retirement savings, they save more in later periods of their working lives, at which point they have higher efficiencies on average.

3.4 Implications for Consumption Tax Reform

The effects of a tax reform is highly sensitive to the conditions of the initial economy. However, studies on tax reforms has taken the progressive tax system at its face value. Results of tax reforms are based on comparisons to baseline economies in which no tax arbitrage opportunity is available. Thus, the effects of a tax reform is potentially overstated when the de facto consumption tax component from TDA is ignored. The purpose of this section is to explore the implications of TDA for a flat tax reform. Here I consider a flat tax reform promoted in Hall and Rabushka (1995) and quantitatively studied in Ventura (1999). By comparing the outcomes of a flat tax reform in the benchmark model to that in a model without TDA (hereafter referred to as the "alternative" model), I examine the extent to which the outcomes of a flat tax reform are affected by the existence of TDA.

With a flat tax reform, the progressive income tax system is replaced by a proportional tax with rate τ_{flat} chosen to maintain government revenue neutrality. Only labor earnings above exemption level $\mathtt{I}^*$ is subject to taxation. Investments are tax deductible (or subsidized if net tax payment is negative) and the same treatment applies to both investments in OAH and TDA. Since OAH receives the same tax treatment as TDA but without any withdrawal constraint, OAH is preferred to TDA. Thus, TDA is redundant and can be dropped from the model. The tax function in (2.9) is replaced by

$$T = \begin{cases} \tau_{flat}\left[we\left(z_j, j\right)l - \mathtt{I}^* + rs - \left(s' - s\right)\right] & \text{if } we\left(z_j, j\right)l > \mathtt{I}^* \\ \tau_{flat}\left[rs - \left(s' - s\right)\right] & \text{otherwise} \end{cases}.$$

Depending on the exemption level, the new tax scheme can be viewed as a progressive consumption tax ($\mathtt{I}^* > 0$) or a proportional tax ($\mathtt{I}^* = 0$). In the case of a progressive consumption tax, $\mathtt{I}^*$ is set to be twenty percent of average household income in the benchmark model. All consumption is subject to taxation under the proportional consumption tax scheme.

Table 3.3: Parameter values of the benchmark and alternative models

	Benchmark (with TDA)	Alternative (without TDA)
β	0.955	0.961
θ	0.324	0.330

Further explanation on model parameter values is needed. If the benchmark model's discount factor (β) and consumption share (θ) are used in the alternative model, the latter one would not be able to match the target capital-output ratio and mean hours specified in section 3. As the goal of this exercise is to highlight that TDA is an important component ignored in a standard model, I re-calibrated the alternative model so that it matches the same target capital-output ratio and mean hours as the benchmark model. The calibrated parameter values of the benchmark and the alternative model are reported in Table 3.3. Since the alternative model excludes the favorable tax treatment on TDA, the discount factor has to be higher than that in the benchmark model to achieve the same capital-output ratio. The absence of tax arbitrage opportunity from TDA also leads to higher effective marginal income tax rates for productive agents, so the consumption share in the utility function also has to be higher in the alternative model to offset the work-leisure substitution effect.

Results of the flat tax reform are reported in Table 3.4. Regardless of the exemption level ($\mathtt{I}^*$) and the existence of TDA, the flat tax reform increases aggregate capital, aggregate labor supply, and output in both the benchmark and the alternative model. These changes are bigger in the case of a proportional consumption tax. Intuitively, since the tax base is larger when there is no tax exemption, the tax rate required to achieve government revenue neutrality is about two percent lower.

More importantly, the quantitative impacts of the flat tax reform in the benchmark model is significantly smaller than that in the alternative model. In the case

Table 3.4: Flat tax reform in the benchmark and the alternative model

Benchmark model

	Progressive	$\mathtt{I}^* = 0.2\chi$	$\mathtt{I}^* = 0.0\chi$
K	1.000	1.275	1.292
N	1.000	1.110	1.130
Mean hours	1.000	1.077	1.102
Y	1.000	1.163	1.182
Earnings Gini	0.31	0.35	0.35
Income Gini	0.48	0.46	0.46
Wealth Gini	0.63	0.64	0.64
τ_{flat}		12.46%	10.55%

Alternative model

	Progressive	$\mathtt{I}^* = 0.2\chi$	$\mathtt{I}^* = 0.0\chi$
K	1.000	1.371	1.392
N	1.000	1.131	1.154
Mean hours	1.000	1.100	1.130
Y	1.000	1.206	1.229
Earnings Gini	0.32	0.39	0.35
Income Gini	0.42	0.51	0.46
Wealth Gini	0.55	0.67	0.64
τ_{flat}		14.43%	12.04%

Note: Columns with header "Progressive" denote the economies with progressive income tax $T(\bullet)$ and proportional capital tax τ_k. The average household income in these economies are denoted as χ. Aggregate capital (K), aggregate efficient labor (N), mean hours, and output (Y) in those economies are normalized to one. Values in the flat tax economies are expressed as fractions relative to their counterparts in the progressive income tax economy.

that $\mathtt{I}^* = 0.2$, aggregate capital increases by 27.5 and 37.1 percent in the benchmark and the alternative model respectively. That means the effects of a flat tax reform on aggregate capital is lowered by 25.9 percent when the effects of TDA are properly considered in the model. Similar differences are observed in the increase in aggregate labor (16.0%), mean hours (23.0%), and output (20.9%).

3.5 Summary and Conclusions

This study investigates the macroeconomic impacts of TDAs and their implications for a flat tax reform. The model in this study includes two key features. First, with endogenous labor supply and a nonlinear tax scheme, this model incorporates the additional tax-saving effect from reallocating taxable income over time through contributions to TDAs. Second, this model also considers the heterogeneity in 401(k) eligibility. Since 401(k) has a much higher contribution limit and is only accessible by a fraction of households, capturing the pattern of 401(k) eligibility is critical in determining the extent of TDA usage in the economy.

Results in this chapter show that TDAs moderately increase the aggregate capital by 3.7 percent. About 65.9 percent of the aggregate capital is held in TDAs, and most of these assets are shifted from households' ordinary accounts, which would have been saved anyway. TDAs have virtually no effect on the aggregate labor supply. As a result, aggregate output only increases by 1.2 percent. When access to 401(k) is given to all households, the aggregate capital further increases by 4.7 percent and the aggregate labor supply only rises by 0.4 percent, resulting in a 1.8 percent increase in aggregate output. Note that extending 401(k) eligibility is an expansion of the TDA system, and hence its consumption tax treatment, with little changes in the current tax code. These results show that increasing the IRA contribution limit, or promoting employers to provide 401(k), is a relatively simple way to increase the aggregate output in the economy.

Although TDAs only have moderate impacts on the aggregate economy, their existence significantly changes households' life-cycle labor supply and saving decisions. With households' upward sloping life-cycle efficiency profiles, the tax-saving effects of TDAs induce households decrease their labor supply when young and increase their labor supply when old. These changes in life-cycle labor supply, together with the effect of tax-free compound growth of assets in TDAs, households accumulate less capital when young but they also possess more capital for retirement.

This chapter demonstrates that neglecting the consumption tax treatment offered by TDAs exaggerates the progressiveness of the income tax code, and overestimates the efficiency loss arise from the distortions in labor supply and capital accumulation decisions. Under a flat tax reform, the increase in aggregate capital and aggregate output in an economy with TDA is 25.9 percent and 20.9 percent lower than that in an economy without TDAs. These results highlight the importance of considering the effects of tax-favored instruments in tax policy analysis.

3.6 Future Research Directions

Future work on this aspect will include a welfare analysis on the introduction of TDAs. Although TDAs only have moderate impacts on the aggregate economy, their influences on household's life cycle decisions imply that TDAs potentially have important effects on welfare. Furthermore, household responses to changes in the income tax rates should further be investigated.

In this study, only conventional IRA and traditional 401(k) are considered. Since Roth IRA was introduced in 1998 and Roth 401(k) was created in 2006, these Roth accounts have become more popular among households. Instead of allowing households to defer their income tax liabilities, contributions to Roth accounts are made from after-tax earnings and subsequent asset withdrawals from Roth TDAs are tax-free. Future research will explore the implications of the coexistence of Roth and traditional TDAs, and study household choices on their types of TDA. This decision problem is of particular interest when the future tax rates are uncertain.

APPENDIX A
CALIBRATION AND EQUILIBRIUM COMPUTATION

The following is an outline of the strategy used to calibrate the benchmark model and the algorithm employed to compute the equilibria in this study:

1. Guess the values of β and θ so that the benchmark model will deliver the targeted capital-output ratio and labor hours.

2. Guess the values of $\left\{\lambda_i^H\right\}_{i=0}^2$ and $\left\{\lambda_j^L\right\}_{j=0}^2$ in the probability function specified in equation (2.16) for an agent's next period 401(k) eligibility.

3. Guess of the steady state values of the aggregate capital (K), aggregate efficient labor supply (N), and accidental bequest (TR).

4. Compute the values of effective wage rate (w), rate of return on capital (r), social security benefits (b), and the calibrated tax brackets cutoff points $\{\mathtt{I}_i\}_{i=1}^5$ in the benchmark model.

5. Discretize the asset spaces into grid points and approximate the labor productivity shocks in (2.4) by a Markov transition matrix by the method described in Tauchen (1986).

6. Calculate the optimal decision rules on consumption $c(x,j)$, labor supply $l(x,j)$, savings as ordinary asset holdings $s(x,j)$, and contributions to TDAs $q(x,j)$ by backward induction.

7. Compute the model-implied aggregate capital stock (K), aggregate efficient labor supply (N), and accidental bequest (TR) in the model.

8. If the model implied values of K, N, and TR in step 7 equals to the guessed values in step 3, then the algorithm has found a steady state equilibrium given

the parameter values in step 1 and 2. Calibration of the benchmark model procceeds to step 9. Otherwise, guess new values and repeat step 4 to 7.

9. Update $\left\{\lambda_i^H\right\}_{i=0}^2$ and $\left\{\lambda_j^L\right\}_{j=0}^2$ to search for the values that minimize the sum of squared error between the model-implied distribution of 401(k) eligibility and its empirical counterpart. Repeat step 3 to 8 for each new guess of $\left\{\lambda_i^H\right\}_{i=0}^2$ and $\left\{\lambda_j^L\right\}_{j=0}^2$.

10. Update β and θ until the benchmark model matches the calibration targets. Repeat step 2 to 9 for each new guess.

Step 1 and 2 are only performed to calibrate the benchmark model. The method used to compute the equilibria, *i.e.* step 3 to 8, is similar to that used in Huggett (1996), Ventura (1999), and Heer and Maussner (2005).

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