Three Essays on Employee Benefits Policy

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Abstract

Households are increasingly responsible for making their own decisions about matters that involve risk. For example, they need to decide how much to save for retirement. Since households often have multiple retirement savings accounts, one interesting question is how savings to one account crowds out savings to other accounts. In Chapter 1, I conduct an event study to estimate how an increase in the contribution rate to one mandatory retirement plan crowds out the total contribution rate to other savings plans, and to this end I examine a novel panel data set for retirement plan contributions of employees at a large public university. Of the particular interest is the fact that the university increased the total contribution rate to a mandatory retirement plan from 10.4% to 13.9% for employees hired on or after July 1, 2010. I find that compared to those hired before the policy change, those hired after the change decreased their contribution rates to voluntary plans by about 2.23 percentage points on average during the first month of employment, but they gradually reached a rate that is not statistically different from the average contribution rate among those hired before the policy change. My results suggest that although new hires respond to the policy change, their response disappears over the long run. One explanation for this phenomenon is that when employees determine their voluntary contribution rate, they follow a rule of thumb that never takes mandated plans into account.

In Chapter 2, I use the same administrative data to test how employees adjusted their contributions to retirement savings plan during the Great Recession. I find that compared to new faculty hired before the Great Recession, those hired during the Great Recession are 11.8 percentage points less likely to participate in the mandatory DC plan, and this estimate is statistically significant at the 1% level. With regard

to the voluntary TDA, I find that compared to new faculty hired before the Great Recession, those hired during the Great Recession are 9.56 percentage points more likely to own a voluntary TDA (significant at the 1% level), but they contribute 1.91 percentage points less to the voluntary TDA (significant at the 1% level). Compared to new staff hired before the Great Recession, those hired during the Great Recession are 9.59 percentage points more likely to own a voluntary TDA (significant at the 1% level), and they contribute 0.41 percentage points more to the voluntary TDA (significant at the 5% level). The voluntary TDA participation rate and the contribution rate among new employees hired after the Great Recession, however, are not statistically different from those hired during the Great Recession.

Chapter 3 estimates the distribution of the risk aversion level from employees' Flexible Savings Accounts (FSAs). An FSA is a tax-preferred financial account into which the employee and the employer (if applicable) put money that the employee can use to pay for medical expenses not covered by the health insurance plan, such as deductible, copayments, and co-insurance. I find that the distribution of the risk aversion coefficient is not a normal distribution and is not a lognormal distribution, and within the same individual it varies a lot across time. This suggests that the constant absolute risk aversion utility function and the constant relative risk aversion utility function should not be used to explain people's choices under uncertainty. Consequently, it may be worthwhile to apply some alternative models, such as the loss aversion model or the probability weighting model, when analyzing the choices made by individual who face risk.

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Contents

Chapter 1

The Crowd Out Effect of Increasing the Mandatory Contribution to Total Retirement Savings

1.1 Introduction

Households are increasingly responsible for making their own decisions about how much to save for their retirement. A defined contribution (DC) pension (for example, a 401(k) account) is a type of retirement plan in which the employer, employee, or both make contributions. The value of assets in private sector DC plans increased from \$74 billion in 1975 to over \$5 trillion in 2013.[1] Saad (2017) reports that more than 50% of future retirees expect to rely on a DC pension as their primary source

[1] U.S. Department of Labor data.

of retirement income.

Making wise decisions about retirement savings is difficult. The fact that households often have multiple retirement savings accounts adds another layer of complexity to the problem.[2] One interesting research question about DC pension is the following: if employers offer multiple retirement savings plans that differ in some plan parameters, how do savings to one plan crowd out savings to other savings accounts?[3] In other words, to what degree do savings to DC plans constitute new savings rather than shifts away from other savings accounts?

Previous work on the crowd-out effect of DC plans has not reached a consensus. On the one hand, Poterba *et al.* (1995), who use data from the Survey of Income and Program Participation (SIPP), find that: a) 401(k) savings do not crowd out savings to other conventional financial accounts; and b) 401(k) savings do not crowd out savings to Individual Retirement Accounts (IRAs) either. Venti & Wise (1992) use the consumer expenditure surveys from 1980 to 1989, SIPP from 1985 to 1987, and the Survey of Consumer Finance (SCF) from 1983 to 1986 to estimate the crowd-out effect of IRA savings. They find that savings to IRAs mainly represent new savings. On the other hand, Engen *et al.* (1994) use SIPP from 1984 to 1991 to conclude that savings to 401(k) plans do not increase private savings or household wealth. Gale & Scholz (1994) analyze 1983-1986 SCF data to find that savings to IRAs do not lead to an increase in national savings. Papke (1999) constructs a novel panel data set from 1985 and 1992 Form 5500 filings and concludes that DC plans are substituting

[2] A common scenario is that households own one 401(k) account from current employer and one Individual Retirement Account (IRA) for rollovers from previous employers. See Munnell *et al.* (2018) for a brief discussion of why multiple accounts makes optimal retirement planning more complicated.

[3] For example, plans can differ in employer contribution rate, mandated employee contribution rate, or match rate.

for DB plans. Poterba *et al.* (1996) and Engen *et al.* (1996) provide detailed reviews of the early literature on the crowd-out effect of 401(k) and IRAs on other savings accounts.

Debate about the crowd-out effect of DC plans has continued in recent years. Some researchers (for instance Gelber (2011); Chetty *et al.* (2014)) find that the increase in DC pension balance represents new savings while others (e.g., Benjamin (2003); Engelhardt & Kumar (2007)) find that the changes in 401(k) savings accounts are shifts from some other financial accounts.

While most previous work has focused on the crowd-out effect among workers in the private sector, recent research has studied a similar effect among workers in the public sector. Beshears *et al.* (2011), for example, review recent behavioral economics studies of retirement savings plans provided by private sector employers and examine how these results can be applied to the public sector. Clark *et al.* (2016), who focus on 403(b) plan participation rates among public school teachers, find much of variation in 403(b) participation decisions cannot be explained by school characteristics (e.g. number of vendors, and school district information provision) and individual characteristics (e.g. annual salary, tenure, position, race, and marital status) In addition, more vendors in 403(b) plans increases the overall participation rate.

In this paper, I exploit an exogenous increase in the total contribution rate (the sum of the employer contribution rate and the mandated employee contribution rate) to a mandatory retirement savings plan of a large public university to investigate whether this increase crowds out faculty savings to other plans. Specifically, faculty at this public university are given a one-time irrevocable opportunity to choose either a DB plan or a DC plan as their mandatory retirement savings plan (the mandatory plan hereafter). Most of them choose the DC plan. For faculty hired before July 1, 2010, the university contributes 10.4% of their monthly pay to the mandatory plan and faculty do not contribute any money to the plan. In 2010, a state law was enacted that mandated a 5% employee contribution rate for all the state employees. In response, the university reduced its employer contribution rate to 8.9% for employees hired on or after July 1, 2010. The total contribution rate, in this case, increased by 3.5 percentage points. In addition to the mandatory plan, faculty can contribute to several different supplementary tax-deferred savings accounts (voluntary plans hereafter).

To study the effect of this policy reform, I first present a simple baseline theoretical model that predicts how this policy change induces changes in the average contribution rate to voluntary plans, conditional on making positive contributions to at least one voluntary plan (average voluntary contribution rate, hereafter) and the average participation rate of voluntary plans (average voluntary participation rate, hereafter). This model assumes: (1) agents are heterogeneous in savings preferences, but the distribution of savings preferences do not change over time; (2) the annual salary agents receive stay the same over time; (3) agents are fully aware of changes in both the employer contribution and the required employee contribution; and (4) their contributions to voluntary plans are high enough that agents always participate in voluntary plans before and after the policy change. The baseline model predicts that the average voluntary contribution rate decreases by 3.5 percentage points while the average voluntary participation rate does not change after the policy change by assumption. I then relax assumption 3 in the model so that the employee contribution rate made to the mandatory plan is more salient than the employer contribution. In this case, the model predicts that the average voluntary contribution rate decreases by more than 3.5 percentage points but by less than 5 percentage points after the policy change. Finally, I relax the last assumption so that some agents can choose to not participate in voluntary plans. My model predicts that the average voluntary contribution rate decreases by less than 3.5 percentage points and the average participation rate also decreases.

To test the model's predictions, I use novel panel data on retirement plan contributions by employees at this university to conduct an event study. I find that compared to those hired before the policy change, faculty hired after the change decrease their contribution rates to voluntary plans by about 2.23 percentage points on average during the first month of employment, but they gradually reach a rate that is not statistically different from the average contribution rate of those hired before the policy change. Compared to previous estimates in the literature, my results show a much bigger response among faculty during the first month of employment but a similar response over the long run. My results suggest that although new hires respond to the policy change, their response disappears over the long run. One possible explanation of this phenomenon is that when employees determine their voluntary contribution rate they follow a rule of thumb that never takes mandated plans into account.

This paper makes contributions to the existing literature in two areas. First, most of the existing literatures use survey results obtained from publicly available datasets in which the income and pension contribution measure can be very noisy and subject to recall bias. My use of administrative data alleviates this problem. Moreover, the policy change I use in this paper is arguably clear and exogenous, in contrast to most of previous works, which do not have a clear exogenous source of variation. Second, most of the literature focuses on how the contribution to employer-sponsored DC plans affects savings to other types of DC plans outside the workplace (how 401(k) crowds out IRA, for example). This paper, in contrast, focuses on the crowd-out effect among employer-sponsored DC plans. Given that employer-sponsored DC plans usually have lower expenses than retail DC savings products (e.g. IRAs), previous estimates in the literature may be confounded by this expense difference as high expense in IRAs may deter employees from responding to the change in their 401(k) accounts.

The rest of this paper is organized as follows. Section 2 describes the institutional details of the large public university recorded in the data. Section 3 introduces a theoretical model that predicts how the average contribution rate to voluntary plans changes when the total contribution rate to the mandatory plan increases. Sections 4 to 7 describe, respectively, the data, empirical strategy, the main results of this paper, and various robustness checks I have conducted. Section 8 concludes.

1.2 Institutional Details

The retirement benefit package of the public university recorded in the data consists of two parts: a mandatory 401(a) retirement savings plan and a voluntary supplemental retirement savings program. On the mandatory plan side, research and teaching faculty and managerial staff of the university can make a one-time irrevocable choice between a DB plan and a DC plan. Most choose the DC plan.[4] Conditional on choosing the DC plan, the total contribution rate to the DC plan depends on the employees' hiring date. For employees hired before July 1, 2010, the university contributes 10.4% of their monthly pay to the DC plan, and employees do not contribute any money to the plan. A state law enacted in 2010 mandates a 5% employee contribution for

[4]The DB plan became a hybrid of DB and DC plan after January 1, 2014, but that is beyond the scope of this paper.

all the state employees.[5] In response, the university reduced it's employer contribute rate to 8.9% for employees hired after July 1, 2010, resulting in a total contribution rate of 13.9%. Table 1.1 summarizes this policy change.

With regards to the voluntary program, the university offers all employees two supplemental DC plans: the 403(b) plan and the 457 plan.[6] These two DC plans resemble the DC plan on the mandatory plan side, except that they offer many more investment choices to the participants.[7] The university automatically enrolls all new employees in the 403(b) plan, which provides a default contribution of $40 per month and a default investment in the Vanguard target date fund that corresponds to employees' estimated dates of retirement after 60 days of their hiring dates. Participants in the 403(b) and 457 plans can change their contribution rates and asset allocations any time. The change takes effect in the following month.

In this paper, I exploit this exogenous increase of the total contribution rate on the mandatory plan side and investigate how newly hired faculty who chose the DC plan as their mandatory retirement savings plan respond to the policy change.

In the following section I present a simple theoretical model that predicts how employees respond to change in the contribution rate mentioned in this section.

[5] The state enacted this legislation to alleviate underfunding problem for its DB plan instead of distorting saving behaviors of DC participants. Therefore this policy change can be treated as exogenous.

[6] Roth options to both plans became available later. I take these options into account in my empirical analysis.

[7] For both plans the university offers a very small match to employee contributions. The match rate is 50 percent of the employee contribution up to a maximum of 40 dollars per month for each plan.

1.3 Model

This section introduces a simple theoretical model that predicts how changes in employer and required employee contributions to the mandatory plan affect employees' participation and contribution decisions regarding voluntary plans.

If the total contribution to the mandatory plan increases, my baseline model predicts that the average voluntary contribution rate decreases by the same amount while the average voluntary participation rate stays the same.[8] However, if some employees cannot reduce their voluntary contributions by as much as the increase in mandatory contribution, then my model predicts that the average voluntary contribution rate decrease with a smaller magnitude than the increase in the mandatory contribution rate. The average voluntary participation rate also will decrease in this case. Yet my model also predicts that if employees are not fully aware changes in both the employer contribution rate and the employee contribution rate, then the average voluntary contribution rates will decrease by an amount that falls somewhere between (a)the change in the total contribution rate to the mandatory plan and (b) the change in mandatory employee contribution rate. The average voluntary participation rate plans, however, stay the same.

Assuming that the employer contribution decreases by 1.5 percentage points and the mandatory employee contribution increases by five percentage points, the total mandatory contribution will increase by 3.5 percentage points, Table 1.2 summarizes my model predictions given various assumptions.

[8]Recall that the average voluntary contribution rate is defined as the average contribution rate to voluntary plans, conditional on making positive contributions to at least one voluntary plan

1.3.1 Setup

Employees live for two periods. They work during the first period and earn a pre-tax income M. Employees must contribute a non-negative amount S_m to the mandatory retirement savings accounts. In addition to the employee contribution, the employer contributes ES_m to the mandatory retirement accounts that cannot be used for consumption during the first period. Employees then have a choice between contributing a non-negative amount S_v to a voluntary retirement savings account and consuming c_1 after paying their income taxes.[9] Note that all the contributions to retirement accounts are not subject to the tax. Employees retire during the second period. The only source of income in the second period is the balance in their retirement savings accounts but these income are subject to income tax in the second period. For the sake of simplicity, I assume that both mandatory and voluntary retirement saving accounts have the same rate of return (r), employees face a flat tax schedule in each period, they cannot borrow in either period, they do not have access to any other savings products, and they want to maintain the same standard of living after they retire.

1.3.2 Baseline Model

In the baseline model, every employee actively optimizes his or her lifetime utility subject to the following constraints: (1) the expenditure on consumption in each period cannot exceed the after-tax take-home pay of that period; and (2) the consumption in the first period is non-negative and consumption in the second period

[9] According to institutional details the contribution to a voluntary retirement savings account receives an employer match of up to $40 per month. This amount is so small that I choose to ignore it. Even when I include the employer match in my model, none of the model predictions change.

is at least the after-tax gross return of the employer contribution. In other words, employee i hired before the policy change solves the following maximization problem:

$$\underset{c_1}{max}\ u_i(c_1^i) + \beta u_i(c_2^i)$$

$$\text{s.t.} \quad p_1 c_1^i = (1-\tau_1)(M - S_v)$$

$$p_2 c_2^i = (1-\tau_2)(1+r)(S_v + ES_m)$$

$$0 \leq p_1 c_1^i \leq (1-\tau_1)M$$

$$(1-\tau_2)(1+r)ES_m \leq p_2 c_2^i \leq (1-\tau_2)(1+r)(M + ES_m)$$

where $u_i(\cdot)$ is a concave function. p_t and τ_t are the price level and tax rate during period t. TS_i is the total savings rate that includes both the mandatory plan and voluntary plans. Note that all the variables with subscript m are related to the mandatory plan, and they are not indexed by i because the mandatory rate is the same for all employees.

Let me talk you through the budget constraints. The left hand side of the first budget constraint, $p_1 c_1^i = (1-\tau_1)(M - S_v)$, is simply the expenditure on consumption in the first period. The right hand side is the after tax take home income. Recall that in the first period, this employee receives a pretax income M. Employer contribution ES_m is not coming from employee's paycheck so it is not subject to the income tax nor should it appear in the employee's budget constraint in the first period. Since the employee is hired before the policy change, he is not required to make any contribution to the mandatory plan, $S_m = 0$. Lastly, the contribution S_v this employee made to the voluntary plan is not subject to income tax in the first period. Hence the taxable income in the first period is $M - S_v$. After tax take home income is then $(1-\tau_1)(M-S_v)$. The second budget constraint is similar to the first one. The left hand side is the expenditure on consumption in the second period and the right hand side is the after tax income in the second period. Note that the only source of income in the second period is the gross return from savings in the first period, which equals to $(1+r)(S_v+ES_m)$, and both the principle and the capital gain are subject to income tax in the second period. Then the after tax income in the second period is $(1-\tau_2)(1+r)(S_v+ES_m)$. The last two budget constraints specifics the lower bound and the upper bound of consumptions in each period. The expenditure on consumption in the first period cannot be negative and it cannot exceed $(1-\tau_1)M$, the after tax take home income if the employee does not contribute to the voluntary plan at all. The expenditure on consumption in the second period is at least $(1-\tau_2)(1+r)ES_m$ because ES_m is the amount of money in the retirement savings account if the employee does not contribute to the voluntary plan at all, and the expenditure on consumption in the second period cannot exceed $(1-\tau_2)(1+r)(M+ES_m)$, the after tax take home income if the employee contributed all of his pretax income in the first period.

Now let's turn to employee j who are hired after the policy change. He solves the same maximization problem as employee i but he faces slightly modified budget constraints:

$$
\begin{gathered}
\underset{c_1}{max}\; u_j(c_1^i) + \beta u_j(c_2^i) \\
\text{s.t.} \quad p_1 c_1^j = (1-\tau_1)(M - S_m - S_v) \\
p_2 c_2^j = (1-\tau_2)(1+r)(S_m + S_v + ES_m') \\
0 \leq p_1 c_1^i \leq (1-\tau_1)(M - S_m) \\
(1-\tau_2)(1+r)(ES_m' + S_m) \leq p_2 c_2^i \leq (1-\tau_2)(1+r)(M + ES_m')
\end{gathered}
$$

The change in the budget constraints is due to the fact that employee j must contribute S_m to the retirement savings account and he faces a different employer contribution ES_m'.

Figure 1.1 is a graphical representation of the baseline model using actual numbers from the policy change. For the sake of simplicity, I assume that the price level is the same across the two periods. BL_1 is the budget line before the policy change. Applying the budget constraints for employee i, the two end points for BL_1 is $c_1 = (1-\tau_1)M, c_2 = (1-\tau_2)(1+r)0.104M$ and $c_1 = 0, c_2 = (1-\tau_2)(1+r)1.104M$ because the employer contribution before the policy change is 10.4% of the employee's monthly pay. Mathematically, these two end point can be derived by plugging $ES_m = 0.104M$ into the last two budget constraint for employee i. Similarly, BL_2 is the budget line after the change. The two end points are $c_1 = (1-\tau_1)0.95M, c_2 = (1-\tau_2)(1+r)0.139M$ and $c_1 = 0, c_2 = (1-\tau_2)(1+r)1.089M$ as $ES_m' = 0.089M, S_m = 0.05M$.

Point A is the optimal consumption bundle for employees hired before the policy change, and point B is the optimal consumption bundle for employees hired after the change under the standard assumption that consumption in both periods are normal goods. The distance between $(1-\tau_1)M$ and C_1^{before} is $(1-\tau_1)S_v^{before}$, the contribution amount to the voluntary plan measured in after tax dollars for employees hired before the policy change. To see this, use the first budget constraint that employee i faces but assume $p_1 = 1$, then we have $c_1 = (1-\tau_1)(M - S_v)$. Rearrange this equation to have $(1-\tau_1)M - c_1 = (1-\tau_1)S_V$. Similarly, the distance between $(1-\tau_1)0.95M$ and C_1^{after} is $(1-\tau_1)S_v^{after}$, the contribution amount to the voluntary plan measured in after tax dollars for employees hired before the policy change.

The change in voluntary plan contribution is then

$$\begin{aligned}(1-\tau_1)S_v^{after} - (1-\tau_1)S_v^{before} &= (1-\tau_1)(S_v^{after} - S_v^{before}) \\ &= (1-\tau_1)0.95M - C_1^{after} - (1-\tau_1)M + C_1^{before} \\ &= -(1-\tau_1)0.05M + C_1^{before} - C_1^{after} \qquad (1.1)\end{aligned}$$

If point A is above segment F of BL_1 (as showed in Figure 1.1) and consumptions in both periods are normal goods, then $0 \leq C_1^{before} - C_1^{after} \leq$ distance D on the graph. Since BL_2 is a parallel shift of BL_1, distance D on the graph is the same as distance E on the graph. Plug $c_2 = (1-\tau_2)(1+r)1.089M, p_2 = 1$ into the second budget constraint faced by employee i to get

$$\begin{aligned}(1-\tau_2)(1+r)1.089M &= (1-\tau_2)(1+r)(S_v + 0.104M) \\ \implies S_v &= 0.035M.\end{aligned}$$

Hence the x-coordinate of point G is $(1-\tau_1)(M - 0.035M) = (1-\tau_1)0.965M$.

Therefore I have

$$\begin{aligned} C_1^{before} - C_1^{after} &\leq (1-\tau_1)0.965M - (1-\tau_1)0.95M \\ &= (1-\tau_1)0.015M. \end{aligned}$$

Given this inequality, I apply it to equation 1.1 to get

$$\begin{aligned} (1-\tau_1)(S_v^{after} - S_v^{before}) &= -(1-\tau_1)0.05M + \underbrace{C_1^{before} - C_1^{after}}_{\text{between 0 and } (1-\tau_1)0.015M} \\ \implies -(1-\tau_1)0.05M &\leq (1-\tau_1)(S_v^{after} - S_v^{before}) \leq -(1-\tau_1)0.05M + (1-\tau_1)0.015M \\ \implies -(1-\tau_1)0.05M &\leq (1-\tau_1)(S_v^{after} - S_v^{before}) \leq -(1-\tau_1)0.035M \\ \implies -0.05M &\leq S_v^{after} - S_v^{before} \leq -0.035M \\ \implies -0.05 &\leq \frac{S_v^{after}}{M} - \frac{S_v^{before}}{M} \leq -0.035 \end{aligned}$$

The last step convert contribution amount into contribution rate, which is a more common measure of retirement contributions than contribution amount. My model predicts that if the total contribution raises by 3.5 percentage points, employees decrease their contribution to the voluntary plans by an amount that falls between 3.5 percentage points and 5 percentage points.

1.3.3 Extended Model

Predictions in the baseline model section relies on two implicit assumptions. First, it assumes that every employee has a voluntary contribution rate that is higher than the change. Second, it assumes that every employee is fully aware of the change in the employer contribution rate and the change in the employee contribution rate, and, therefore the only thing that matters to the employees is the rate of total contribution to the mandatory plan. If both assumptions hold, the average participation rate in voluntary plans does not change. In this subsection, I show how model predictions changes if I relax one of these assumptions.

If the first assumption is violated, employees who cannot fully offset the change in the mandatory contribution rate choose not to participate in voluntary plans. Graphically, it means that point A is on Figure 1.1 is on segment F of the budget line instead. Then after the policy change, these agents will be bunching at point H on the graph. Then $C_1^{before} - C_1^{after} \leq (1-\tau_1)M - (1-\tau_1)0.95M = (1-\tau_1)0.05M$ because the most extreme case is where point I is the optimal consumption bundle before the policy change and point H is the optimal consumption bundle after the policy change. Following the same analysis used in the baseline model section,

$$(1-\tau_1)(S_v^{after} - S_v^{before}) = -(1-\tau_1)0.05M + \underbrace{C_1^{before} - C_1^{after}}_{\text{between 0 and } (1-\tau_1)0.05M}$$

$$\implies -(1-\tau_1)0.05M \leq (1-\tau_1)(S_v^{after} - S_v^{before}) \leq -(1-\tau_1)0.05M + (1-\tau_1)0.05M$$

$$\implies -0.05 \leq \frac{S_v^{after}}{M} - \frac{S_v^{before}}{M} \leq 0.$$

The model prediction is that if the total contribution raises by 3.5 percentage points and some people cannot fully offset the change , employees decrease their contribution to the voluntary plans by an amount that falls between 0 percentage points and 5 percentage points.

If the second assumption is violated, one possibility is that employees notice the 5% increase in the employee contribution but not the 1.5% decrease in the employer contribution rate. Then employees would perceive BL_1 shifts to BL_3 instead. Then

$$(1-\tau_1)(S_v^{after} - S_v^{before}) = -(1-\tau_1)0.05M + \underbrace{C_1^{before} - C_1^{after}}_{\text{between 0 and } (1-\tau_1)0.05M}$$

$$\implies -(1-\tau_1)0.05M \leq (1-\tau_1)(S_v^{after} - S_v^{before}) \leq -(1-\tau_1)0.05M + (1-\tau_1)0.05M$$

$$\implies -0.05 \leq \frac{S_v^{after}}{M} - \frac{S_v^{before}}{M} \leq 0.$$

Hence the model prediction on changes in contribution rate is the same as the model prediction above. However, voluntary plan participation rate, in this case, does not change.

Although I cannot easily test whether employees are fully aware of the changes in both the employer contribution and the employee contribution, a simple tabulation from my data suggests that the assumption that every employee has a voluntary contribution rate that is higher than the relevant change is indeed violated. Only 38.13% of new hires made before the policy change contributed more than 3.5 percentage points of their monthly pay during the month they joined the university. The fraction decreases to 30.06% if I increase the threshold to 5 percentage points.

Recall the policy change mentioned in the institutional details section wherein the mandatory employer contribution decreased by 1.5 percentage points and the mandatory employee contribution increased by 5 percentage points. The baseline model predicts that in this case, the average voluntary contribution rate decreases by somewhere between 3.5 percentage points and 5 percentage points while the average voluntary participation rate stays the same. If the first assumption is violated, the average voluntary rate is predicted to decrease by somewhere between 0 percentage points and 5 percentage points. The average voluntary participation rate also decreases. If the second assumption is violated, the average voluntary rate is predicted to decrease by more than 0 percentage points but by less than 5 percentage points. However, the average voluntary participation rate does not change.

1.4 Data

I construct a novel panel dataset using a university's administrative record from January 2004, to June 2018, and other publicly available data. The administrative data contain monthly retirement plan information, semiannual demographics information, and annual earnings collapsed into bins by the data provider in order to eliminate concerns that an individual could be identified. Retirement plan information contains employee and employer (if applicable) contribution rates to all available retirement savings plans each year; recall that this includes contribution rates to both the mandatory plan and voluntary plans. Demographics information includes employee gender, age collapsed into bins due to privacy concerns, marital status (which, for reasons discussed later, is imperfectly observed), hiring year, and category of employment (faculty versus staff). To control for macroeconomic conditions, I also include publicly available variables, such as annual inflation rate and monthly returns on the Standard & Poor 500 index.

The annual earnings of employees are collapsed into bins to avoid potential identity leaks. However, it is undesired in regressions to use earnings bands rather than earnings amount because using binned income does not capture the true variance of the effect of income on outcome variables. Therefore, to impute the earnings amount, I use publicly available data on the distribution of annual earnings by faculty in a single year and I draw randomly from the appropriate band in the publicly available data. For earnings bins that are not included in the public record, I assume that the distribution of those earnings bins is uniform. Figure 1.2, which compares the distribution of imputed annual earnings (the solid curve) to earnings distribution from the public record (the dash curve), shows that the distribution of imputed earnings is close to the distribution of earnings in the publicly available data.

The initial panel data contain 573,772 observations representing 7,509 faculty over 14 years. I exclude 181,442 observations made during summer months[10] because faculty do not receive regular pay during the summer. Consequently, it is possible that faculty adjust their contribution rate to voluntary plans because of variation in their monthly pay rather than because of changes in the parameters of their retirement plans. I also exclude 1,739 observations with arrears payment in any retirement savings plan in any year because individuals with arrears payment can be subject to different budget constraints.[11] Finally, I remove 150 observations with annual income less than $10,000 because these observations probably represent faculty who worked at the university for a very short period of time.

Recall that changes in the total contribution rate to the mandatory plan apply only to new hires made after July 1, 2010. Therefore, I create two samples from the cleaned panel data by including only newly hired faculty since 2004. The first sample is a cross-sectional sample that uses observations from the first month that faculty are hired. It contains 2,697 observations, each of which represents one unique individual. The second sample extends the cross-sectional sample to a 3-year panel sample by using observations from the first three calendar years after faculty are hired. It contains 49,895 observations of 2,697 newly-hired faculty. Note that each observation

[10]Summer months include May, June, July, and August.

[11]Arrears are a period when the employee should have contributed to the plan, but did not.

in the second sample represent a unique person-month combination. Since I exclude observations made during summer month, an individual can appear 24 times in the data at maximum.

Table 1.3 shows the fraction, drawn from the cross-sectional sample, of new hires who choose either the DC plan or the DB plan. Figure 1.3 shows the choice between the DB and the DC plan among new hires by year. The black dots in the graph represent the fraction of new hires who choose the DC plan each year. The solid line around black dots represents the average participation rate in the DC plan among those hired before the policy change, while the black dash line around dots represents the average among those hired after the policy change. Similarly, red triangles represent fractions of new hires who choose the DB plan each year. The red solid line and the red dash line around triangles show the average of the fractions for new hires before and after the policy change. Although Table 1.3 shows that after the policy change new hires are more likely to choose the DB plan, Figure 1.3 shows that such difference is mainly driven by events happened after 2010 such as the introduction of Roth options as Figure 1.3 shows that new hires in 2013 are significantly less likely to choose the DC plan. However, the fraction of faculty who chose the DC plan did not undergo a significant change around 2010, the year of the policy change. How faculty choose between the DB and the DC plan is outside the scope of this paper, but to be thorough I include Table 1.5, which shows the OLS estimation results for the probability that new hires will choose the DC plan as their mandatory retirement savings plan. Using all years of data, those hired after the policy change are 11.9 percentage points less likely to choose the DC plan than those hired before the policy change. However, if I only use new hires between 2008 and 2012 to exclude the significant drop in 2013 depicted in Figure 1.3, the change in the probability is small and not statistically different from zero. This indicates that the policy change in this paper does not alter the composition of people who choose the DC plan. Therefore, I only exclude faculty who choose the DB plan as their mandatory retirement savings plan from both the cross-sectional sample and the 3-year panel sample. The final sample size is 2,397 observations for the cross-sectional sample and 45,903 observations for the 3-year panel sample. For readers who are concerned about the DC plan participants after 2013 may have different savings preferences than DC plan participants before 2013, I include regression results using data from 2008 to 2012 in the robustness check section as the fraction of newly-hired faculty who choose the DC plan is very stable during this time period.

1.4.1 Descriptive Statistics

The summary statistics table below uses the cross-sectional sample to show demographics for faculty before and after the policy change. According to Table 1.4, faculty before and after the policy change do not differ much in terms of gender, whether they work in full time, or annual income. Although the difference in the mid-point of the age band is statistically significant, the difference is not economically significant. The only red flag in Table 1.4 is the dramatic change in the fraction of faculty who are married. After the policy change, the fraction of newly hired faculty who are married decreased by seven percentage points, but the decrease reflects not a real decrease but a change due to documentation practices. Employees are not required to report their marital status to the university, and consequently the fraction of newly hired faculty with unknown marital status increased - by over ten percentage points. The reg flag mainly reflects an increasing fraction of employees whose marital status is missing.

Figures 1.4, 1.5, and 1.6 show how demographics variables evolve each year. In all three graphs, lines with the same color represent the same variable. However, the solid part of each line uses data from new hires made before the policy change while the dash part of each line uses data from new hires made after the policy change. The red line with squares in Figure 1.4 represents the fraction of faculty who were hired as full-time employees in each year – a fraction that does not vary much. The orange line with crosses shows the fraction of female faculty who were hired in each year, and this fraction, too, is quite stable. The gap in 2010 is a sampling issue: less than twenty faculty are hired before July of that year. The rest three lines represent marital status. Since the administrative data do not document complete information about marital status, they are not very informative. Figure 1.5 and 1.6 show how age and imputed income evolve each year. Both average age and average imputed annual income are very stable across the years. All three graphs show that newly hired faculty do not differ much in terms of observables.

1.4.2 Graphical Results

Before examining the empirical results,I present some graphical results using raw data. Figures 1.7 and 1.8 show the average voluntary participation rate and the average voluntary contribution rate each year using the cross-sectional sample. The black circles represent tax-deferred accounts (TDAs) in voluntary plans, the blue diamonds represent Roth accounts, and the red triangles include both TDAs and Roth accounts. The solid lines show the averages of new hires before the policy change for different account types. Similarly, the dashed lines show the averages of new hires after the policy change for different account types. Since Roth accounts were not available to employees before 2013, black circles and red triangles overlap with each other prior to 2013. As indicated in Figure 1.7, when I take into account both Roth accounts and TDAs, the average voluntary participation rate decreases insignificantly. Similarly, Figure 1.8 indicates that after the policy change, the average voluntary contribution rate decreases by about two percentage points.

Figures 1.9 and 1.10 show that using the 3-year panel sample, the average voluntary participation rate and the average voluntary contribution rate changed over time for newly hired faculty before and after policy change. The difference between solid lines with label "Total/TDA" and dashed lines with label "Total" in Figure 1.7 and Figure 1.8 can be observed as the gap between the black bars and the gray bars at month zero in Figures 1.9 and 1.10, respectively.[12] In both graphs, new faculty hired after the policy change started with lower values, but over time the difference became progressively smaller. Three years after their employment date, the differences in both the average participation rate and the average contribution rate are small. A general take-away from these four graphs is that employees responded to the increase in their mandatory contribution rate by not participating in voluntary plans and by reducing their contribution rate to voluntary plans, as predicted. However, these responses disappears over time.

In the next two sections I present empirical specifications and main results that mimic the four graphs just described and I quantify employees' responses to the policy change.

[12]Since I excluded summer months, the 3-year sample ends up with 24 months instead of 36 months.

1.5 Empirical Strategy

This paper investigates whether the increase in the total contribution rate induced any change in participation and contribution decisions about voluntary plans. The first specification uses the cross-sectional sample that only includes observations from the first-month that new faculty are employed. I follow an event study specification to estimate the response to the policy change. Thus, I estimate the equation below using the OLS:

$$\begin{aligned} y_{it} = {} & \beta_1 \text{Post}_i + \beta_2 \text{Female}_i + \beta_3 \text{Income}_{it} + \beta_4 \text{Full time}_{it} \\ & + \beta_5 \text{Married}_i + \beta_6 \text{Single}_i + \beta_7 \text{Stock return}_{it} + \sum_{j=1}^{12} \beta_j \text{Age Band}_j + \epsilon_{it}. \end{aligned} \tag{1.2}$$

I run the regression on four outcome variables: an indicator of owning at least one TDA, the total contribution rate to TDAs, an indicator of owning any retirement savings accounts, and the total contribution rate to all retirement savings accounts. The first and last two outcome variables differ in the respect that retirement savings accounts include both TDAs and Roth accounts. $Post_i$ takes a value of one if the faculty is hired on or after July 1, 2010. $Income_{it}$ is the imputed annual income for the employee measured in thousands and converted to 2018 dollars. Full time$_{it}$ is an indicator that takes a value of one if the faculty is hired as a full-time employee. Stock return$_{it}$ is the monthly return on the S&P 500 index. Since I omitted the constant, coefficients in front of age bands should be interpreted as relative to the average age. The specification does not include year fixed effects because they will absorb the treatment effect of the policy change. The coefficient of interest is then

β_1.

The first specification assumes faculty respond immediately to the policy change and that the response persists afterward. However, faculty can change their participation and contribution decision at any time. Therefore using the 3-year panel sample, I estimate the equation below to allow variation in the treatment effect during different tenure months:

$$
\begin{aligned}
y_{it} = {} & \beta_1 \text{Female}_i + \beta_2 \text{Income}_{it} + \beta_3 \text{Full time}_{it} \\
& + \beta_4 \text{Married}_i + \beta_5 \text{Single}_i + \beta_6 \text{Stock Return}_{it} + \sum_j \beta_j \text{Age Band}_j \\
& + \sum_i \beta_i \text{tenure month}_{it} + \sum_k \beta_k \text{tenure month}_{it} \times Post_t + \epsilon_{it}.
\end{aligned} \tag{1.3}
$$

tenure month_{it} are indicators for each month on or after faculty are hired, and all other variables is defined the same as in the first specification.

The identification assumption of both specifications is that newly hired faculty before and after the policy change do not differ systematically in their saving preferences. Figures 1.4, 1.5, and 1.6 in the data section show that faculty do not differ much in terms of observables and there is no reason to believe that faculty would differ much in terms of unobservables. However, if newly hired faculty do differ systematically in some unobservables that lead to different saving preferences, then estimation results will be biased. The direction of bias depends on how unobservables correlate with outcome variables. One possible concern in both specifications is that I do not include marginal tax rate in either specification and changes in the tax system from 2004 to 2018 may potentially bias my result. I do not include marginal tax rate for two reasons. First, marginal tax rate is not available in the data. To impute marginal tax rate for each faculty, I need to make additional assumptions about his tax situation. In addition, incomplete marital status information makes the imputation even harder. Second, the only major change in the income tax system from 2004 to 2018 is the American Taxpayer Relief Act of 2012, which introduced a new 39.6% tax bracket. Most of faculty should not be affected by this tax reform.

1.6 Results

Table 1.6 shows the estimation results of equation 1.2. Both the participation rate and the contribution rate are measured in percentage points. The first two columns of table 1.6 consider only TDAs while the last two columns of table 1.6 consider both TDAs and Roth accounts. New faculty hired after the policy change are 3.25 percentage points less likely to own a voluntary retirement savings account than new faculty hired before the policy change, although the difference is not statistically significant. Conditional on owning at least one voluntary retirement savings account, the total contribution rate to all voluntary savings accounts for faculty hired after the policy change is 2.23 percentage points lower than the contribution rate among faculty hired before the policy change. Since the decrease in the contribution rate to voluntary retirement savings plans is less than 3.5 percentage points (the increase in total mandatory contribution rate), it matches my model prediction that some employees who are not able to fully offset the changes in the mandatory plan contribution rate as their intended contribution rate to the voluntary plans are less than 3.5 percentage points. If they want to fully offset the changes in the mandatory plan, they need to contribute negative amount to the voluntary plans, which is, impossible.

In the robustness checks section, I report estimation results using Tobit instead of the OLS to account for this natural left censorship at zero.

Table 1.7 shows the estimation results of equation 1.3. To save space, I only report coefficients of the interaction of the tenure month and post. As in Table 1.6, the first two columns only consider TDAs and the last two columns also include responses to Roth accounts. All four columns show a similar pattern: whether or not Roth accounts are taken into consideration, the average participation rate and the average contribution rate to voluntary plans among new faculty hired after the policy change are statistically lower than those among new faculty hired before the policy change. However, the differences get smaller over time.

Compared to previous estimates in the literature, my results show a much bigger response among faculty during the first month of employment but similar responses over the long run. For example, Chetty *et al.* (2014) estimate that individuals decrease their contribution rate to retirement savings plans by 0.02 percentage points for every percentage point increase in the employer contribution rate. My estimates show that faculty decrease their total contribution rate to voluntary plans by 2.23 percentages points during the first month of their employment for every 3.5 percentage points increase in the total contribution rate to a mandatory plan. Surprisingly, such responses disappear after three years. In other words, the estimated long-run effect is comparable to what Chetty *et al.* (2014) report. A possible explanation of this phenomenon is that employees are aware of changes in the mandatory plan but when they determine their voluntary contribution rate, they follow a rule of thumb that never takes mandated plans into account.

1.7 Robustness Check

In this section I present couple robustness checks of my results. First, I examine whether my results are sensitive to covariates included in the regression. Second, I examine whether my estimates are sensitive to the time periods used in the analysis. In the previous section my results use data from 2004 to 2018. However, some events, such as the introduction of Roth options in voluntary plans, happened at later dates, which could bias my estimates. The third check concerns whether my estimates are sensitive to estimation strategy used in the analysis. I focus on the estimation results using my cross-sectional sample and take into account both TDAs and Roth accounts (i.e., the last two columns in Table 1.6).

1.7.1 Covariates Concern

In this subsection, I compare my results from the previous section to the results if I drop all the covariates but include only a constant in my specifications. In other words, I estimate the following specification:

$$y_{it} = \beta_1 \text{Post}_i + \beta_0 + \epsilon_{it}.$$

Table 1.9 compares estimations of equation 1.2 with estimation of the equation above. According to Table 1.9, point estimates change by less than 0.5 percentage points if I drop all of the covariates. The average voluntary participation rate decreases by 3.47 percentage points when I exclude all the covariate instead of 3.25 percentage points, but it remains statistically insignificant. The average voluntary contribution rate decreases by 1.88 percentage points instead of 2.23 percentage points.

I conclude that my main results are not sensitive to covariates included in the regression.

1.7.2 Time Periods Concern

In this subsection, I address two concerns on the time periods used in the analysis. The first concern is that later events, such as the introduction of Roth options in 2013, may change the composition of newly-hired faculty. Consequently, those who are hired after 2013 may not share the same savings preferences as those who are hired before 2013. I re-estimate equation 1.2 using data from 2008 to 2012 so that I have the same number of years before and after the policy change. The second concern is that those who are hired during the great recession may behave differently from those who are hired in some other time. So I present another set of estimation results using data from 2005 to 2007, and from 2010 to 2012 to eliminate the potential effect from both the great recession and later events. Recall that my specification is

$$\begin{aligned} y_{it} &= \beta_1 \text{Post}_i + \beta_2 \text{Female}_i + \beta_3 \text{Income}_{it} + \beta_4 \text{Full time}_{it} \\ &\quad + \beta_5 \text{Married}_i + \beta_6 \text{Single}_i + \beta_7 \text{Stock return}_{it} + \sum_{j=1}^{12} \beta_j \text{Age Band}_j + \epsilon_{it}. \end{aligned}$$

Table 1.10 compares regression results using different time frames. The first three columns show my regression results on the average participation rate using data from 2008-2012, data from 2005-2007 and 2010-2012, and data from 2004-2018, respectively. Similarly, the last three columns of Table 1.10 show regression results on the average contribution rate on the corresponding time frames.

By including only newly-hired faculty from 2008 to 2012, those who hired after the policy change are 5.67 percentage points less likely to participate in the voluntary plans. Conditional on participate in the voluntary plans, the average voluntary contribution rate among those who are hired after the policy change is 0.3 percentage points less than the average voluntary contribution rate among those who are hired before the change. Although both estimates are no longer statistically significant, they have the same sign as estimates in my main results. Therefore, the events happened in later dates have limited impact on my estimations. On the other hand, if I include only new hires from 2005 to 2007, and from 2010 to 2012 to further eliminate possible effects from the great recession, those who are hired after the policy change is 8.1 percentage points more likely to participate in voluntary plans. Conditional on participate in the voluntary plans, the average voluntary contribution rate among those who are hired after the policy change is 3.6 percentage points less than the average voluntary contribution rate among those who are hired before the change. In other words, compared to new faculty hired before the great recession, those who are hired after the policy change are more likely to participate in the voluntary plans but made less contributions to the voluntary plans. One justification is that since the Fed significantly lowered interest rate after the great recession, so new faculty hired after 2010 are more likely to participate in the voluntary plans. However, given the great recession just passed, they choose to investment a smaller fraction of wealth into the stock market.

1.7.3 Strategy Concern

Since employees cannot contribute negative amount to the voluntary plans, another natural specification is to estimate a Tobit version of my specification on contribution rate to the voluntary plans:

$$contribution_{it} = \begin{cases} contribution^*_{it} & \text{if } y^*_{it} > 0 \\ 0 & \text{otherwise,} \end{cases}$$

and

$$\begin{aligned} contribution^*_{it} = \beta_1 \text{Post}_i + \beta_2 \text{Female}_i + \beta_3 \text{Income}_{it} + \beta_4 \text{Full time}_{it} \\ + \beta_5 \text{Married}_i + \beta_6 \text{Single}_i + \beta_7 \text{Stock return}_{it} + \sum_{j=1}^{12} \beta_j \text{Age Band}_j + \epsilon_{it}. \\ \epsilon_{it} \sim N(0, \sigma^2). \end{aligned}$$

Table 1.11 compares estimation results using the Tobit model to the estimation results in the main text. Using Tobit model, the average voluntary contribution rate among newly-hired faculty after the policy change is 2.24 percentage points less than the average voluntary contribution rate among those who are hired before the change. The point estimate is almost identical to the estimate obtained using the OLS. Consequently, I conclude that my results are not sensitive to the estimation strategy used in the analysis.

1.8 Conclusion

In this paper, I exploit an exogenous increase in the total contribution rate to a mandatory retirement savings plan at a large public university to investigate whether this increase crowds out faculty savings to other plans. I first present a simple baseline theoretical model that uses some simply assumptions to predict how this policy change induces changes in the average voluntary contribution rate and the average voluntary participation rate. The baseline model predicts that the average voluntary contribution rate decreases by 3.5 percentage points while the average voluntary participation rate does not change after the policy change. I then relax one of the assumptions so that some employees can choose to not participate in voluntary plans. My model predicts that the average voluntary contribution rate decreases by less 3.5 percentage points and the average participation rate also decreases. To test the model's predictions, I conduct an event study that uses a novel panel data on retirement plan contributions of employees at the university. I find that compared to new employees hired before the policy change, those hired after the policy change decrease their contribution rates to voluntary plans by about 2.23 percentage points during the first month of their employment. Surprisingly, three years after their employment date, the response disappears. Therefore, the estimated long run effect is consistent with previous findings reported in the literature. One justification for the difference between short-run and long-run response is that employees are aware of changes in the mandatory plan but over the long run, they follow a rule of thumb that never takes mandated plans into account when they determine their voluntary contribution rate.

In the future, I hope to extend this work in two directions. First I will collect data on the historical performance of mandatory and voluntary plans and perhaps conducting a survey that asks about future performance expectations for the mandatory and the voluntary plans. If the historical performance or the expected future performance of the two plans differs significantly, I will need to relax the model's assumption so that the mandatory retirement savings plan and the voluntary retirement savings plans do not have the same return rate. Consequently, the model prediction could be different. Second, I will find a proper control group in the panel data. Although current results from event study are robust, having a good control group and re-estimating the treatment effect using a difference-in-differences specification can alleviate concern that there is a systemic difference in saving preferences for newly-hired faculty before and after the policy change.

Table 1.1: Summary of the policy change

Hiring Date	Before July 1, 2010	On or after July 1, 2010
Mandated Employee Contribution Rate	0%	5%
Employer Contribution Rate	10.4%	8.9%
Total Contribution Rate	10.4%	13.9%

Note: State legislation mandates a 5% employee contribution rate by all state employees to alleviate underfunding problem for its DB plan rather than distorting saving behaviors of its DC plan participants. Therefore, this policy change can be treated as exogenous.

Table 1.2: Summary of model predictions

Assumption	Average voluntary contribution rate	Average voluntary participation rate
Baseline	Decreased by more than 3.5 percentage point but less than 5 percentage points	No change
Baseline + can't fully adjust	Decreased by more than 0 percentage point but less than 5 percentage points	Decrease
Baseline + not fully aware	Decreased by more than 0 percentage point but less than 5 percentage points	No change

Note: The baseline model assumes: (1) agents share the same retirement savings goal; (2) the annual salary agents receive stay the same over time; (3) agents are fully aware of changes in both the employer contribution and the employee contribution; and (4) their contributions to voluntary plans are high enough that agents always participate in voluntary plans before and after the policy change.

Table 1.3: Fraction of new hires who choose DC vs. DB as their mandatory savings plan

	New hires before July 1, 2010				New hires on/after July 1, 2010			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
DC plan participation	94.97%	21.87%	0	1	0.00%	0.00%	0	0
DC plan participation, after policy change	0.00%	0.00%	0	0	83.75%	36.90%	0	1
DB plan participation	5.19%	22.20%	0	1	0.00%	0.00%	0	0
DB plan participation, after policy change	0.00%	0.00%	0	0	16.25%	36.90%	0	1
Observations	1232				1465			

Note: Recall that every faculty in the university has to make a one-time irrevocable choice between a DB plan and a DC plan as his mandatory retirement savings plan. The data source for this table is the cross-sectional sample, which only contains observations for the first month faculty are hired.

Table 1.4: Summary statistics on demographics variable using the first month data

	Before July 1, 2010				On/After July 1, 2010				
	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max	Diff in mean
TDAs Participation Rate	67.69%	46.79%	0	1	54.28%	49.84%	0	1	
TDAs Contribution Rate	8.09	13.85	0.1	90.7	6.07	10.88	0.1	80	
Roth Participation Rate	N/A				14.02%	34.73%	0	1	
Roth Contribution Rate					4.96	7.95	0	59	
Total Participation	67.69%	46.79%	0	1	64.22%	47.95%	0	1	
Total Contribution	8.09	13.85	0.1	90.7	6.21	10.79	0	80	
Female	41.11%	49.22%	0	1	43.11%	49.54%	0	1	-0.02
Married	42.99%	49.53%	0	1	34.47%	47.55%	0	1	0.085***
Single	24.36%	42.94%	0	1	21.43%	41.05%	0	1	0.029*
Unknown	32.65%	46.91%	0	1	44.09%	49.67%	0	1	-0.114***
Full time	96.58%	18.18%	0	1	96.66%	17.98%	0	1	-0.001
Real imputed annual income (in thousands)	106.19	63.22	36.20	884.50	110.17	77.40	32.89	780.59	-3.976
Mid-point of age band	39	9	27.5	67.75	38	8	27.5	77.75	0.936***
Observations	1170				1227				

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.5: Estimation on fraction of new hires who choose the DC plan as their mandatory plan

	All Data	2008-2012
Post	-0.119***	-0.0285
	(0.0116)	(0.0226)
Female	0.00667	0.0298
	(0.0124)	(0.0214)
Imputed Annual Income (in '000s)	0.000287**	0.000386*
	(0.0000920)	(0.000161)
Full time Employee	0.0440	0.0697
	(0.0386)	(0.0763)
Married	-0.0309*	-0.0491*
	(0.0132)	(0.0229)
Single	-0.0526**	-0.0306
	(0.0162)	(0.0262)
Stock Return	-0.000853	-0.000751
	(0.00122)	(0.00152)
Age Bands		
[25,30)	0.927***	0.879***
	(0.0447)	(0.0890)
[30,35)	0.930***	0.856***
	(0.0419)	(0.0836)
[35,40)	0.923***	0.874***
	(0.0422)	(0.0798)
[40,45)	0.892***	0.835***
	(0.0444)	(0.0873)
[45,50)	0.838***	0.729***
	(0.0481)	(0.0981)
[50,55)	0.851***	0.748***
	(0.0496)	(0.103)
[55,59.5)	0.785***	0.726***
	(0.0578)	(0.105)
[59.5,62)	0.850***	0.772***
	(0.0713)	(0.141)
[62,65)	0.821***	0.585**
	(0.0852)	(0.226)
[65,70.5)	0.820***	0.391
	(0.0882)	(0.275)
[70.5,85)	0.579	0.977***
	(0.360)	(0.0831)
N	2692	700

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.6: OLS estimation of equation 1.2 using the first month data on new hires each year

	TDAs, First Month Data		TDAs + Roth, First Month Data	
	Participation	Contribution	Participation	Contribution
Post	-12.98***	-2.411***	-3.249	-2.227***
	(2.021)	(0.677)	(1.981)	(0.650)
Female	2.769	-0.544	-0.296	-0.487
	(2.024)	(0.661)	(1.990)	(0.633)
Imputed Annual Income (in ’000s)	0.0465**	0.00218	0.0545***	0.00203
	(0.0149)	(0.00391)	(0.0143)	(0.00373)
Full time Employee	1.392	-2.652	-2.518	-1.838
	(5.441)	(2.360)	(5.379)	(2.101)
Married	3.829	-1.427	4.297*	-1.250
	(2.253)	(0.759)	(2.191)	(0.722)
Single	-3.266	-0.997	-2.316	-1.120
	(2.713)	(0.883)	(2.683)	(0.825)
Stock Return	-0.656***	0.167**	-0.647***	0.160**
	(0.194)	(0.0541)	(0.188)	(0.0531)
Age Bands				
[25,30)	57.43***	7.917**	61.42***	7.217**
	(6.788)	(2.446)	(6.707)	(2.205)
[30,35)	59.37***	10.93***	64.97***	10.20***
	(6.125)	(2.457)	(6.029)	(2.204)
[35,40)	59.26***	12.10***	63.74***	11.08***
	(6.252)	(2.428)	(6.137)	(2.169)
[40,45)	62.43***	12.18***	64.53***	11.35***
	(6.488)	(2.572)	(6.389)	(2.345)
[45,50)	61.77***	13.49***	62.88***	12.73***
	(6.914)	(2.694)	(6.814)	(2.487)
[50,55)	54.40***	15.11***	58.19***	13.66***
	(7.492)	(3.142)	(7.358)	(2.909)
[55,59.5)	65.22***	14.46***	64.57***	13.76***
	(7.882)	(3.263)	(7.645)	(3.100)
[59.5,62)	48.26***	10.71***	49.20***	9.935***
	(11.31)	(3.188)	(11.01)	(2.973)
[62,65)	49.33***	9.525*	49.92***	8.624*
	(12.90)	(4.050)	(12.33)	(3.750)
[65,70.5)	43.87**	9.126*	42.38**	8.439*
	(14.28)	(3.802)	(14.09)	(3.698)
[70.5,85)	105.4***	6.797**	98.36***	5.653**
	(6.447)	(2.387)	(6.311)	(2.171)
N	2397	1458	2397	1580

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.7: Estimation result of equation 1.3 using 3-year panel data

	TDAs, 3 Years Data		TDAs + Roth, 3 Years Data	
	Participation	Contribution	Participation	Contribution
Tenure Month× Post				
0	-14.23***	-2.191***	-4.373*	-2.052***
	(1.972)	(0.645)	(1.933)	(0.622)
1	-15.67***	-1.677**	-5.165**	-1.531**
	(1.914)	(0.611)	(1.849)	(0.593)
2	-15.85***	-1.706**	-5.328**	-1.550**
	(1.879)	(0.619)	(1.804)	(0.601)
3	-15.75***	-1.702**	-5.367**	-1.579**
	(1.874)	(0.608)	(1.795)	(0.590)
4	-14.54***	-1.137*	-3.975*	-1.126*
	(1.881)	(0.525)	(1.786)	(0.506)
5	-14.76***	-0.830	-4.199*	-0.816
	(1.879)	(0.518)	(1.786)	(0.497)
6	-13.10***	-0.900	-2.545	-0.773
	(1.871)	(0.503)	(1.769)	(0.489)
7	-13.56***	-0.786	-3.087	-0.606
	(1.870)	(0.513)	(1.761)	(0.498)
8	-10.87***	-0.794	-1.326	-0.868
	(2.026)	(0.622)	(1.882)	(0.590)
9	-10.06***	-0.555	-0.504	-0.648
	(2.038)	(0.635)	(1.893)	(0.603)
10	-10.22***	-0.382	-0.984	-0.414
	(2.036)	(0.624)	(1.889)	(0.593)
11	-11.18***	-0.277	-1.893	-0.314
	(2.047)	(0.568)	(1.902)	(0.538)
12	-11.63***	-0.534	-2.070	-0.513
	(2.040)	(0.556)	(1.882)	(0.531)
13	-11.73***	-0.405	-2.350	-0.275
	(2.036)	(0.563)	(1.880)	(0.540)
14	-12.72***	-0.649	-3.060	-0.543
	(2.030)	(0.554)	(1.862)	(0.531)
15	-12.07***	-0.988	-2.276	-0.844
	(2.044)	(0.545)	(1.861)	(0.529)
16	-8.847***	-1.236*	1.814	-1.311*
	(2.157)	(0.614)	(1.877)	(0.588)
17	-9.507***	-0.859	1.320	-0.975
	(2.193)	(0.677)	(1.913)	(0.648)
18	-9.857***	-0.378	0.890	-0.591
	(2.203)	(0.711)	(1.917)	(0.668)

Table 1.8: Continues

	TDAs, 3 Years Data		TDAs + Roth, 3 Years Data	
	Participation	Contribution	Participation	Contribution
19	-10.47***	-0.386	0.543	-0.631
	(2.219)	(0.719)	(1.929)	(0.675)
20	-11.09***	-0.368	0.244	-0.566
	(2.212)	(0.697)	(1.910)	(0.658)
21	-10.52***	-0.688	0.614	-0.833
	(2.211)	(0.649)	(1.907)	(0.620)
22	-10.88***	-0.456	0.0873	-0.665
	(2.234)	(0.694)	(1.928)	(0.660)
23	-8.197***	-0.785	2.265	-0.971
	(2.246)	(0.689)	(1.906)	(0.653)
24	-5.226*	-1.128	4.102*	-1.228
	(2.367)	(0.718)	(1.991)	(0.695)
Control variables in specification 1	Yes			
N	44858	33125	44858	35314

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.9: OLS estimation results with and without covariates

	TDAs + Roth, First Month Data			
	Participation	Participation	Contribution	Contribution
Post	-3.471	-3.249	-1.876**	-2.227***
	(1.935)	(1.981)	(0.625)	(0.650)
Female		-0.296		-0.487
		(1.990)		(0.633)
Imputed Annual Income (in '000s)		0.0545***		0.00203
		(0.0143)		(0.00373)
Full time Employee		-2.518		-1.838
		(5.379)		(2.101)
Married		4.297*		-1.250
		(2.191)		(0.722)
Single		-2.316		-1.120
		(2.683)		(0.825)
Stock Return		-0.647***		0.160**
		(0.188)		(0.0531)
Age Bands				
[25,30)		61.42***		7.217**
		(6.707)		(2.205)
[30,35)		64.97***		10.20***
		(6.029)		(2.204)
[35,40)		63.74***		11.08***
		(6.137)		(2.169)
[40,45)		64.53***		11.35***
		(6.389)		(2.345)
[45,50)		62.88***		12.73***
		(6.814)		(2.487)
[50,55)		58.19***		13.66***
		(7.358)		(2.909)
[55,59.5)		64.57***		13.76***
		(7.645)		(3.100)
[59.5,62)		49.20***		9.935***
		(11.01)		(2.973)
[62,65)		49.92***		8.624*
		(12.33)		(3.750)
[65,70.5)		42.38**		8.439*
		(14.09)		(3.698)
[70.5,85)		98.36***		5.653**
		(6.311)		(2.171)
Constant	67.69***	N/A	8.087***	N/A
	(1.368)		(0.492)	
N	2397	2397	1580	1580

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.10: OLS estimation with different time frames

	TDAs + Roth, First Month Data					
	Participation Rate			Contribution Rate		
	2008-2012	05-07,10-12	All Years	2008-2012	05-07,10-12	All Years
Post	-5.665	8.067*	-3.249	-0.299	-3.598***	-2.227***
	(3.541)	(3.165)	(1.981)	(1.071)	(0.977)	(0.650)
Female	-1.383	3.088	-0.296	0.0562	-0.814	-0.487
	(3.342)	(3.098)	(1.990)	(0.995)	(1.031)	(0.633)
Imputed Annual Income (in '000s)	0.0830**	0.0336	0.0545***	-0.00133	0.00540	0.00203
	(0.0273)	(0.0234)	(0.0143)	(0.00652)	(0.00767)	(0.00373)
Full time Employee	-3.609	-8.132	-2.518	-2.794	-1.995	-1.838
	(8.948)	(7.613)	(5.379)	(3.029)	(2.574)	(2.101)
Married	5.424	2.051	4.297*	-1.567	-0.946	-1.250
	(3.651)	(3.332)	(2.191)	(1.075)	(1.204)	(0.722)
Single	-2.469	-4.753	-2.316	-1.796	-2.168	-1.120
	(4.602)	(4.192)	(2.683)	(1.396)	(1.202)	(0.825)
Stock Return	-0.436	0.419	-0.647***	0.0548	-0.0546	0.160**
	(0.230)	(0.396)	(0.188)	(0.0645)	(0.113)	(0.0531)
Age Bands						
[25,30)	68.99***	72.41***	61.42***	6.696*	7.725**	7.217**
	(11.29)	(9.715)	(6.707)	(3.266)	(2.850)	(2.205)
[30,35)	76.22***	70.07***	64.97***	9.420**	11.11***	10.20***
	(9.835)	(8.709)	(6.029)	(3.230)	(2.844)	(2.204)
[35,40)	75.58***	67.88***	63.74***	10.38**	11.93***	11.08***
	(10.15)	(8.950)	(6.137)	(3.335)	(2.946)	(2.169)
[40,45)	72.66***	69.84***	64.53***	9.920**	12.27***	11.35***
	(10.56)	(9.161)	(6.389)	(3.546)	(3.235)	(2.345)
[45,50)	63.28***	76.58***	62.88***	11.41*	12.85***	12.73***
	(12.20)	(9.692)	(6.814)	(4.441)	(3.328)	(2.487)
[50,55)	66.17***	64.93***	58.19***	12.75*	19.17***	13.66***
	(12.39)	(10.81)	(7.358)	(5.489)	(4.707)	(2.909)
[55,59.5)	93.05***	56.51***	64.57***	10.37*	16.46*	13.76***
	(8.948)	(12.51)	(7.645)	(4.061)	(6.878)	(3.100)
[59.5,62)	47.57*	51.52**	49.20***	8.378	8.101*	9.935***
	(21.89)	(17.79)	(11.01)	(5.056)	(4.103)	(2.973)
[62,65)	34.29	39.62	49.92***	5.303	5.202	8.624*
	(33.49)	(24.18)	(12.33)	(5.323)	(3.347)	(3.750)
[65,70.5)	88.79***	69.16***	42.38**	5.652	10.91	8.439*
	(9.878)	(19.50)	(14.09)	(3.344)	(5.576)	(3.698)
[70.5,85)	97.78***	94.11***	98.36***	5.541	7.108*	5.653**
	(10.40)	(9.302)	(6.311)	(3.173)	(2.919)	(2.171)
N	641	984	2397	501	682	1580

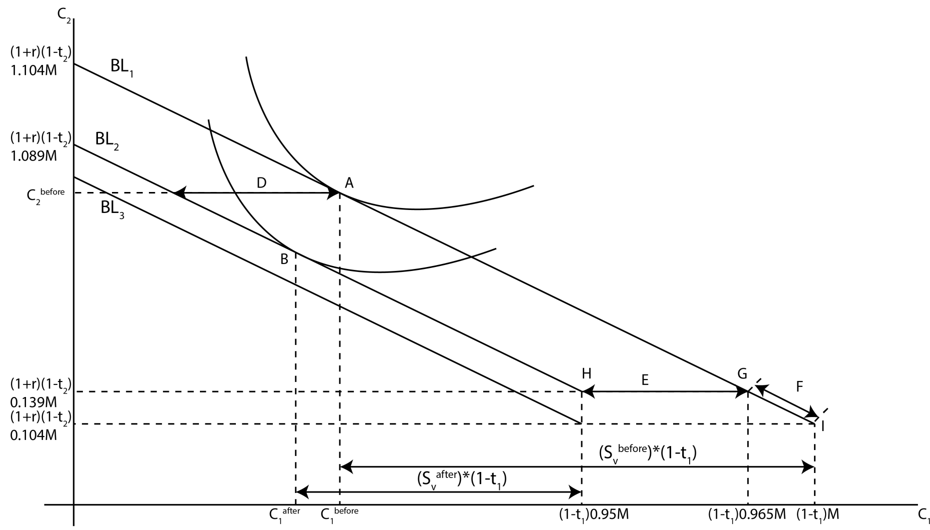
Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.11: Tobit estimation vs OLS estimation on contribution rate

	TDAs + Roth, First Month Data	
	Tobit	OLS
Post	-2.244***	-2.227***
	(0.627)	(0.650)
Female	-0.350	-0.487
	(0.618)	(0.633)
Imputed Annual Income (in '000s)	0.0126**	0.00203
	(0.00393)	(0.00373)
Full time Employee	-1.945	-1.838
	(1.938)	(2.101)
Married	-0.0862	-1.250
	(0.702)	(0.722)
Single	-1.311	-1.120
	(0.818)	(0.825)
Stock Return	0.00421	0.160**
	(0.0550)	(0.0531)
Age Bands		
[25,30)	0.274	7.217**
	(2.102)	(2.205)
[30,35)	3.081	10.20***
	(2.033)	(2.204)
[35,40)	3.491	11.08***
	(2.019)	(2.169)
[40,45)	3.904	11.35***
	(2.160)	(2.345)
[45,50)	4.606*	12.73***
	(2.308)	(2.487)
[50,55)	4.204	13.66***
	(2.688)	(2.909)
[55,59.5)	5.615	13.76***
	(2.870)	(3.100)
[59.5,62)	-0.347	9.935***
	(3.252)	(2.973)
[62,65)	-1.141	8.624*
	(3.758)	(3.750)
[65,70.5)	-3.025	8.439*
	(3.942)	(3.698)
[70.5,85)	4.080*	5.653**
	(2.072)	(2.171)
N	1580	1580

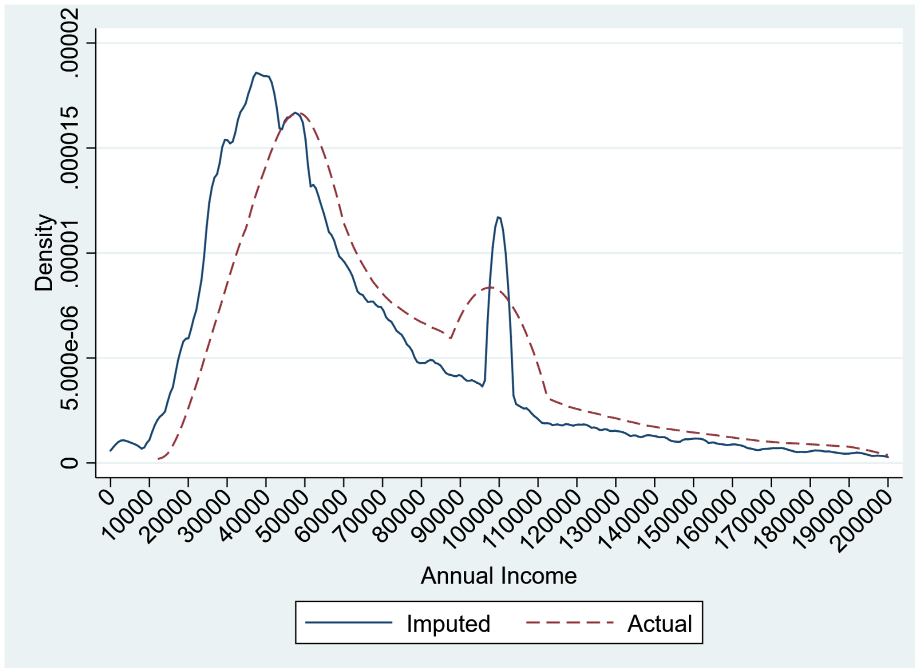
Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1.1: Graphical representation of model



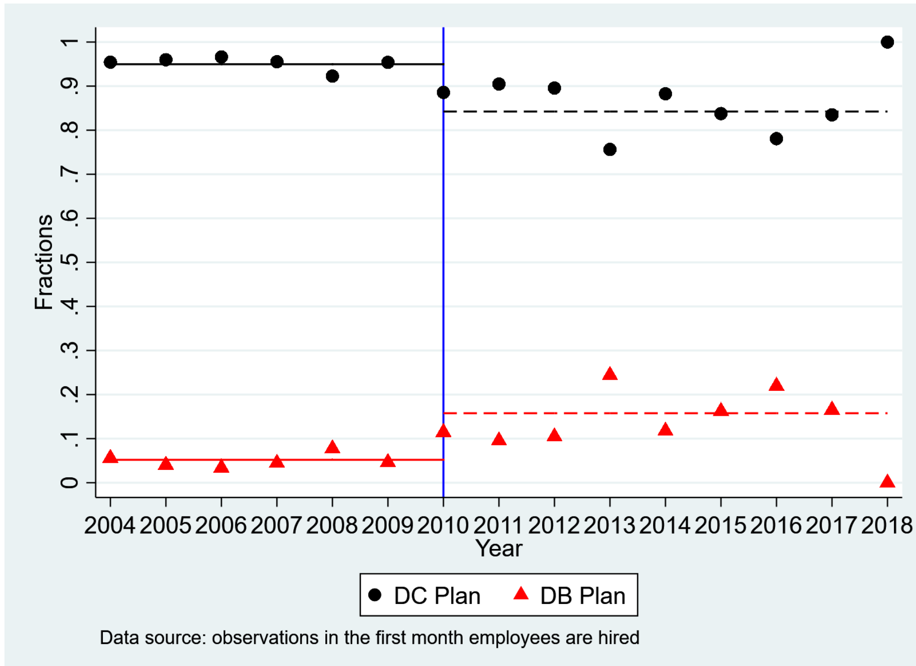
Note: For the sake of simplicity, I assume that the price level do not change for this graph. Point A is the optimal consumption bundle for employees hired before the policy change. Point B is the consumption bundle for employees hired after the policy change if they share the same savings goal as employees hired before the policy change. Point C is the optimal consumption bundles under the standard assumption that consumption in each period is a normal good.

Figure 1.2: Distribution of imputed annual income vs. distribution of actual annual income



Note: The solid line represents the distribution of imputed annual earnings and the dashed line represents the actual distribution of annual earnings from the public record.

Figure 1.3: Choice between DB and DC plan among new hires in each year

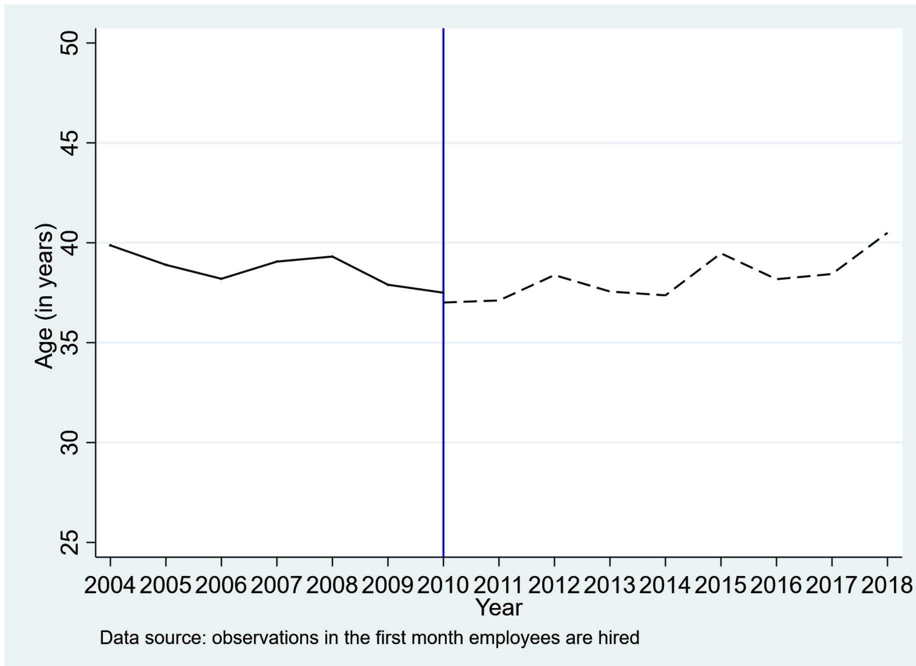


Note: The fraction of new hires who choose the DC plan each year are represented in the graph by black circles. The black solid line around these circles represents the average rate of participation in the DC plan among those hired before the policy change, while the black dashed line around these circles represents the average among those hired after the policy change. Similarly, red triangles represent fractions of new hires who choose the DB plan each year. The red solid line and the red dashed line around triangles show the average of the fractions for new hires before and after the policy change.

Figure 1.4: Fraction of gender, marital status, and full time worker in each year for newly hired faculty

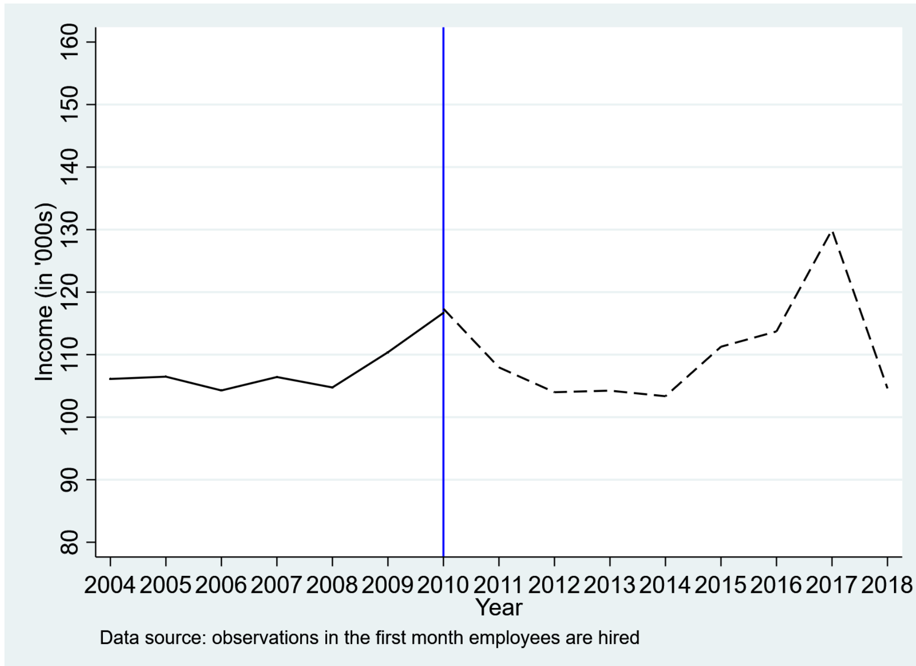
Note: Lines with the same pattern represent the same variable. However, the solid part of each line uses data from new hires before the policy change while the dashed part of each line uses data from new hires after the policy change.

Figure 1.5: Average age for newly hired faculty by year



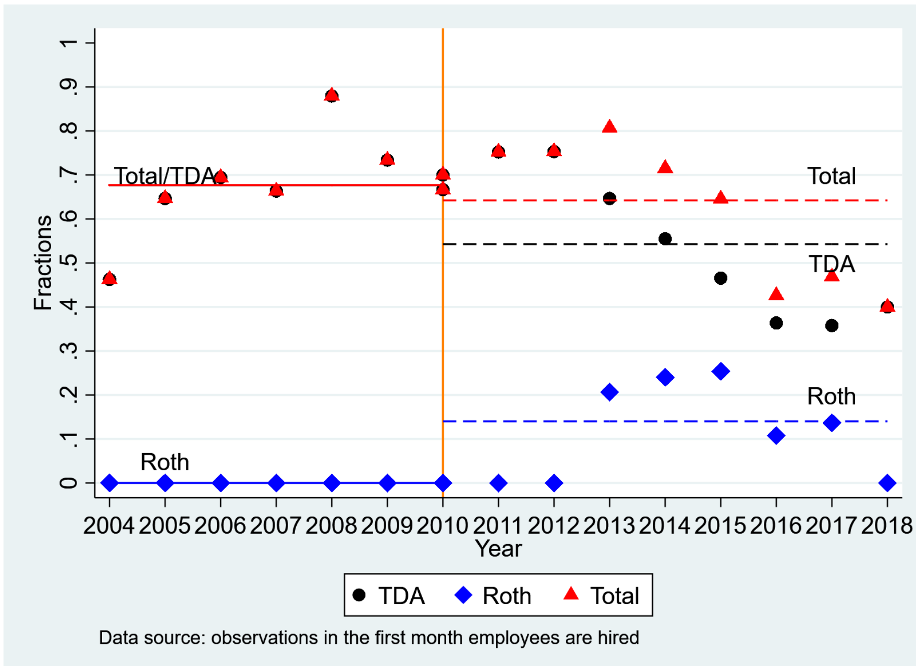
Note: The solid line uses data from new hires before the policy change and the dashed line uses data from new hires after the policy change.

Figure 1.6: Average annual imputed income for newly hired faculty by year



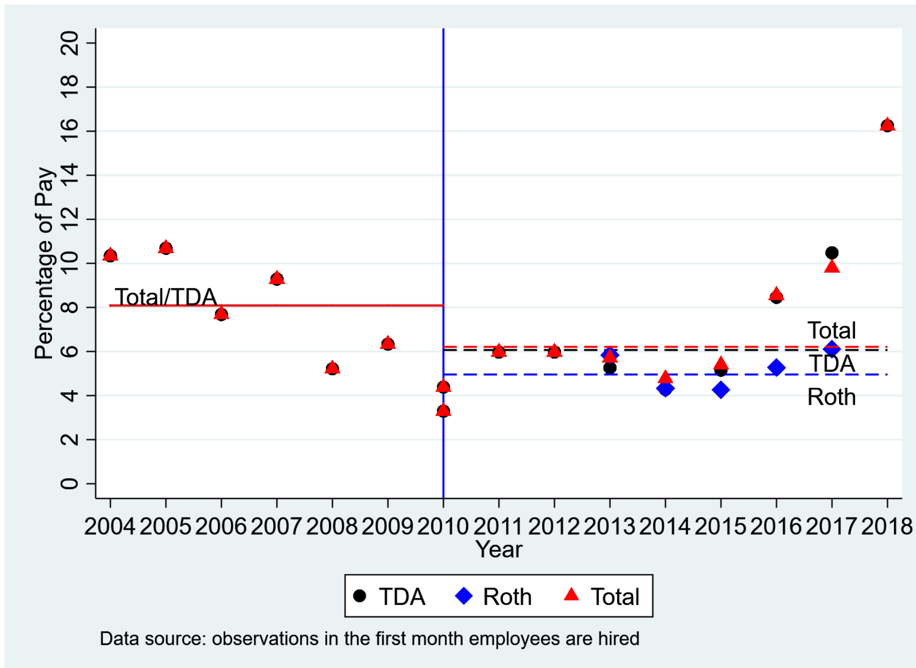
Note: The solid line uses data from new hires before the policy change while the dashed line uses data from new hires after the policy change. The imputed income is measured in 2018 dollars.

Figure 1.7: Average voluntary participation rate among new hires by plan type by year



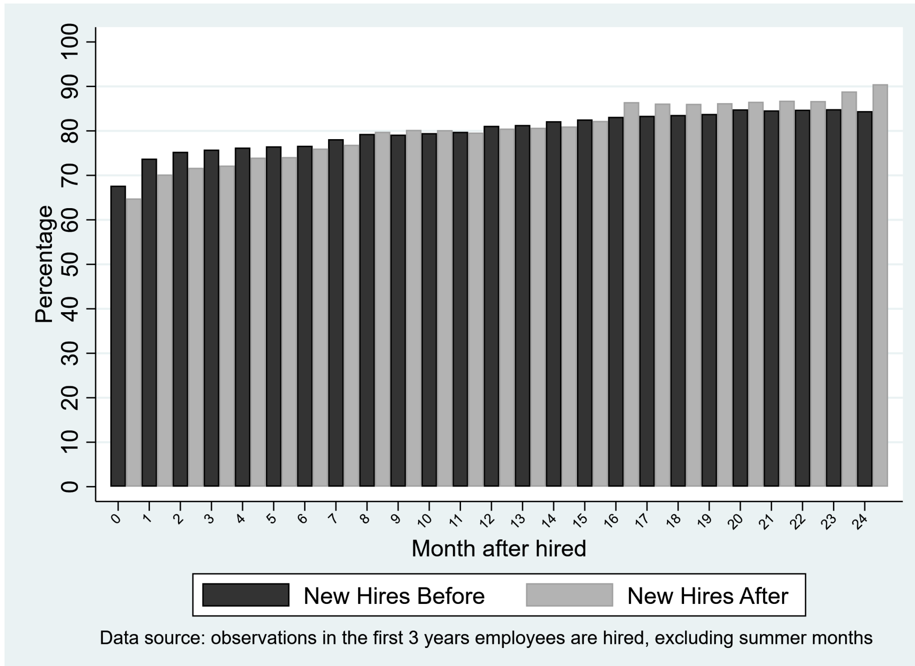
Note: The solid lines use data from new hires before the policy change while the dashed lines use data from new hires after the policy change. Red triangles represent the average voluntary participation rate each year. It includes both TDAs and Roth accounts. Black circles and red triangles overlap with each other before 2013 because Roth options are not available until 2013. Roth participation rate is zero in 2018 because the data ends in June, 2018 but only a few faculty were hired before June in each year.

Figure 1.8: Average voluntary contribution rate among new hires by plan type by year



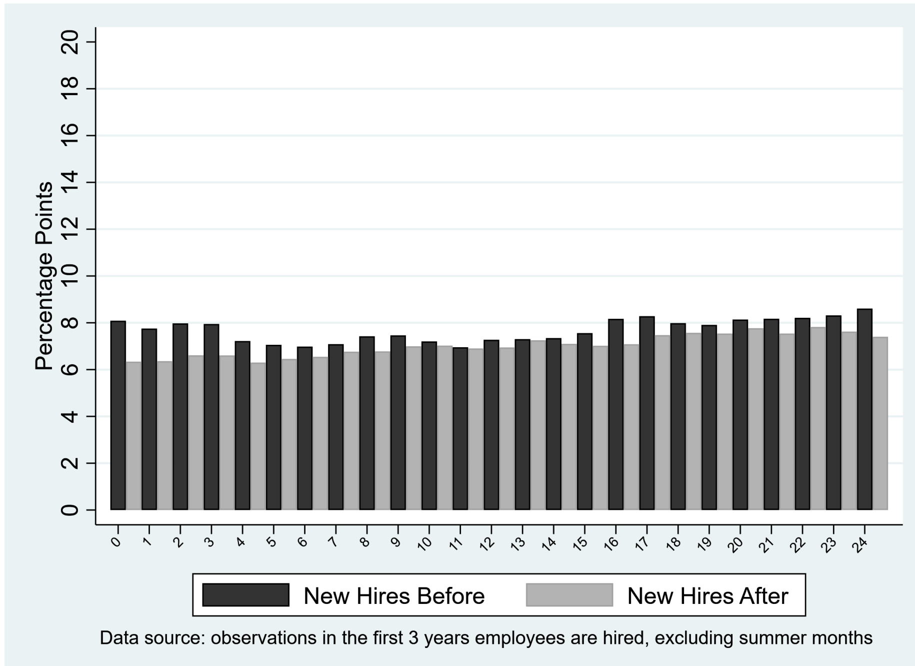
Note: The solid line uses data from new hires before the policy change while the dashed lines use data from new hires after the policy change. Red triangles represent the average voluntary participation rate each year. It includes both TDAs and Roth accounts. Black circles and red triangles overlap with each other before 2013 because Roth options are not available until 2013.

Figure 1.9: Average voluntary participation rate among new hires by tenure month



Note: The participation rate in this graph includes both TDAs and Roth accounts. The data used in this graph track for three calendar years after their hiring dates of the same people in Figure 1.7. However, observations made during May, June, July, and August of each year are removed. Consequently, the graph only shows 24 months for a three-year time period.

Figure 1.10: Average voluntary contribution rate among new hires by tenure month



Note: The contribution rate in this graph includes contributions made to both TDAs and Roth accounts. The data used in this graph track for three calendar years after their hiring dates of the same people in Figure 1.8. However, observations made during May, June, July, and August are removed. Consequently, the graph only shows 24 months for a three-year time period.

Chapter 2

The Impact of the Great Recession on Pension Choices

2.1 Introduction

Households are increasingly responsible for making their own decisions about how much to save for their retirement. A defined contribution (DC) pension (for example, a 401(k) account) is a type of retirement plan in which the employer, the employee, or both make contributions. Participants in DC pension control the investment choices in these plans, subject to the fund offerings that employers have selected. The value of assets in private sector DC plans increased from \$74 billion in 1975 to over \$5 trillion in 2013.[1] The DC plans have become the most prevalent type of retirement plan in the United States (see Buessing & Soto (2006); Copeland (2005, 2010); Costo (2006); Gustman *et al.* (2009); Purcell & Division (2005); Purcell (2009); Rajnes (2002); Solis & Hall (2010)). More recently, Saad (2017) reports that more than 50%

[1] US Department of Labor data.

of future retirees expect to rely on a DC pension as their primary source of retirement income.

Making good decisions about retirement savings is difficult. Households need to solve two complex problems: determining which plan to participate in; and identifying the optimal asset allocation strategy. When making decisions, households also need to take into account possible tax consequences. See Madrian & Shea (2001) and Pratt (2001) for a brief explanation of why making optimal decisions about DC pension is complex. The fact that households often have multiple retirement savings accounts adds another layer of complexity to the problem.[2]

Given the complexity of these problems, households can make sub-optimal decisions about their retirement savings. For example, Choi *et al.* (2005) find that employees fail to utilize the employer match on their retirement savings plan and essentially leave about 1.3 percent of their pretax income on the table. In addition, multiple research has shown the "power of default options," which suggests that workers are reluctant to solve the complex retirement savings problem. [3]

This empirical finding leads to an interesting research question: What kind of role does expected investment return rate play in households' decision-making process about DC pension? The finance literature has not reached consensus about how individual investors react to price changes. For example, results from Kaniel *et al.* (2008); Dhar & Kumar (2001) indicate that individual investors are more likely to buy stocks when the stock price is falling and sell stocks when pricing is rising. On the other hand, Goetzmann & Massa (2002); Grinblatt *et al.* (1995) show that some

[2] A common scenario is that households own one 401(k) account from current employer and one Individual Retirement Account (IRA) for rollovers from previous employers. See Munnell *et al.* (2018) for a brief discussion of why multiple accounts make optimal retirement planning more complicated.

[3] The effect of changing default options for the retirement savings plan on pension choices is beyond the scope of this paper. Please see Beshears *et al.* (2009) for an overview.

investors purchase stock when the market is rising and sell stocks when the market is crashing. See Barber & Odean (2013) for an overview of the behavior of individual investors. However, the lesson learned from the "power of defaults" provides a third possibility: because households pay little attention to their DC pensions, stock market performance should have no effect on their pension choices.

This paper joins a broader literature that investigates the effect of the Great Recession on household wealth, various labor market outcomes, and various retirement-related outcomes. Maurer *et al.* (2012) provide an overview of key lessons and conclusions learned from the Great Recession. Bricker *et al.* (2011); Hurd & Rohwedder (2010, 2012); Coronado & Dynan (2012) use various data sources, including 2007-2009 Survey of Consumer Finance (SCF) panel, American Life Panel, and Health and Retirement Study (HRS), to document the effect of the Great Recession on household wealth and labor market outcomes. They find that during the Great Recession, most families experienced a decline in household wealth. Households also reduced their spending, deferred their retirement date, and, by increasing their desired level of buffer savings, showed greater caution after the Great Recession by increasing their desired level of buffer savings. One drawback in this research is that there is no regression analysis. These researchers reach their conclusions by comparing various summary statistics that do not control for factors such as individual characteristics, income level, etc. Mody *et al.* (2012) use data from OECD countries to estimate the relationship between the savings rate and income uncertainty. Modelling the Great Recession as an exogenous increase in income uncertainty, they find that about 40% of the increase in family savings during the Great Recession was due to precautionary savings. Walden (2012) uses data from the Federal Reserve to address a similar question.

The existing literature also documents differences in responses of different demographics groups to the Great Recession. For example, examining data from a university survey of 2,799 employees, Zick *et al.* (2013) find that older cohorts responded to the Great Recession by working longer before retirement and reducing risks associated with their retirement assets. Coile & Levine (2015) use data from Current Population Survey and HRS to conclude that more-skilled workers chose to delay their retirement time but less-skilled workers decided to retire earlier.

Another series of studies focus on outcomes specifically associated with the DC plan. For example, Argento *et al.* (2015) use Statistics of Income data from 2004 to 2010 with year fixed effects to show that early withdrawals from retirement accounts increased during the Great Recession and afterward, but the magnitude was modest. Holden *et al.* (2010) conclude that five percent of DC plan participants stopped contributing to their plan in 2009 – a 1.3 percentage point increase from 2008. Researchers from Vanguard use its administrative record to conclude that although the stock market is extremely volatile, there is little change in the retirement plan participation rate and contribution rate during the Great Recession (see Pagliaro & Utkus (2009a,b); Utkus & Young (2009, 2010)).[4] However, Yao *et al.* (2013); Dushi *et al.* (2013), who use SCF, the Survey of Income and Program Participation (SIPP), and tax data as their sample, and find that the contribution rate among DC plan participants dropped significantly during the Great Recession. Examining tax data and SIPP, Tamborini *et al.* (2013) conclude that the probability of observing a substantial decrease in the contribution rate is positively related to the unemployment level in the industry which plan participants work, but it is negatively associated with the

[4] The contribution rate is defined as the amount of money the participant puts in his retirement plan divided by his pretax income.

size of the firm.

In this paper, I assume that the decrease in the stock market return during the Great Recession was independent of other factors that can alter individual retirement savings choices, and I investigate whether this drop in stock market return has any impact on the pension choices of the employees who work at a large public university. This analysis complements the work of Tamborini *et al.* (2013), who focus on DC pension choices among private sector workers. Faculty at this public university are given a one-time irrevocable opportunity to choose either a Defined Benefit (DB) plan or a DC plan as their mandatory retirement savings plan (the "mandatory plan" hereafter). Most choose the DC plan. The university contributes 10.4% of a faculty member's pretax monthly pay to the mandatory plan, and faculty do not contribute any money to the plan. Staff, on the other hand, can only choose the DB plan. In addition to the mandatory plan, all the employees of this university can contribute to a 403(b) Tax Deferred savings Account (referred to hereafter as a "voluntary TDA").

To estimate the effect of the Great Recession on pension choices, I use the same the empirical strategy employed by Argento *et al.* (2015), Yao *et al.* (2013), and Dushi *et al.* (2013), but I also use novel panel data on retirement plan contributions of employees at the university. On the mandatory plan side, I find that compared to new faculty hired before the Great Recession, those hired during the Great Recession are 11.8 percentage points less likely to participate in the DC plan, and this estimate is statistically significant at the 1% level. On the voluntary TDA side, I find that compared to new faculty hired before the Great Recession, those hired during the Great Recession are 9.56 percentage points more likely to own a voluntary TDA (significant at the 1% level), but they contribute 1.91 percentage points less to the voluntary TDA (significant at the 1% level). Compared to new staff hired before the

Great Recession, those hired during the Great Recession are 9.59 percentage points more likely to own a voluntary TDA (significant at the 1% level) and contribute 0.41 percentage points more to the voluntary TDA (significant at the 5% level). However, voluntary TDA participation rates and contribution rates among new employees hired after the Great Recession are not statistically different from those of employees hired during the Great Recession. These results confirm the findings of Dushi *et al.* (2013) that inertia did not play a very important role in households pension choices during the Great Recession. Indeed, I observe significant changes in the average plan participation rate and the average plan contribution rate.

I then extend my analysis to see how new employees respond to stock market changes in general. I find that for every percentage point of increase in the monthly return rate of the S&P 500 index, the probability that new faculty choose the DC plan as their mandatory retirement savings plan increases by 0.99 percentage points (significant at the 1% level). For every percentage point of increase in the monthly return rate of the S&P 500 index, new faculty are 0.56 percentage points less likely to own a voluntary TDA (significant at the 10% level) but contribute 0.16 percentage points more to their accounts (significant at the 1% level); new staff are 0.23 percentage points less likely to own a TDA and contribute 0.03 percentage points less to their accounts. Both estimates among new staff are not statistically significant.

Last, I conduct a similar analysis among employees hired before January 2004 ("existing employees" hereafter). My regression results indicate that for every percentage point increase in the stock market return rate, existing faculty are 0.16 percentage points more likely to own a voluntary TDA (not statistically significant), and they contribute 0.03 percentage points more to the voluntary TDA (significant at the 5% level). Existing staff are 0.006 percentage points less likely to own a voluntary TDA, and contribute 0.002 percentage points less to the voluntary TDA. Both estimates among existing staff are not statistically significant.

This paper makes contributions to the existing literature in two areas. First, most previous research has focused on private sector workers. This paper, in contrast, focuses on the response among employees in the higher education industry. Employees in the higher education industry, and specially faculty in public universities, differ from private sector workers in two respects. First, public sectors employees are offered more retirement savings choices. University employees have access to 403(b) and 457 plans in addition to a 401(k) plan, whereas private sector workers often only have access to a 401(k) plan. In other words, workers in the public sector have more choices for their retirement savings plan. Also, public sector workers, on average, face a lower unemployment rate. Hence, during the Great Recession they were less concerned about losing their jobs. Second, in my data set I can track changes in employee behavior over time whereas most previous studies that examine administrative data cannot track particular individuals over time.

The rest of this paper is organized as follows. Section 2 describes the institutional details of the large public university recorded in the data. Sections 3 to 6 describe, respectively, the data, the empirical strategy, the main results of this paper, and the various robustness checks that I have conducted. Section 7 concludes.

2.2 Institutional Details

The retirement benefits package of the public university recorded in the data consists of two parts: a mandatory 401(a) retirement savings plan and a voluntary TDA. In the mandatory plan, university research and teaching faculty and managerial staff can make a one-time irrevocable choice between a DB plan and a DC plan, while other employees can only choose the DB plan. Employees eligible for the DC plan must make their decisions within 60 days of their employment; about 70% of them choose the DC plan. During the periods studied in this paper, DB plan participants contributed 5% of their pre-tax income to the plan while DC plan participants did not make any contributions to the mandatory DC plan.

With regards to the voluntary TDA, the university offers all employees a supplemental 403(b) plan, which is a DC plan. The 403(b) plan resembles the DC plan on the mandatory plan side except that it offers participants a wider range of fund choices from multiple vendors that cover the usual range of asset classes (bond, equity, and real-estate) to the participants.[5] Participants in the plan can change their contribution rates and asset allocations any time. The change takes effect in the following month.

With respect to stock market performance, Figure 2.1 shows the performance of the Standard & Poor (S&P) 500 index between January 1, 2004 and July 1, 2010. The two red vertical lines indicate the starting and ending month of the Great Recession. During the Great Recession, the S&P 500 index decreased by about 40%, representing a significant drop in household wealth.

[5] For the 403(b) plans the university offers a very small match to employee contributions. The match rate is 50 percent of the employee contribution up to a maximum of 40 dollars per month for each plan.

2.3 Data

2.3.1 Sample Description

I construct a novel panel data set using a university's administrative record from January 2004 to June 2018, and some other publicly available data. The administrative data contains monthly retirement plan information, semiannual demographics information, and annual earnings collapsed into bins by the data provider to eliminate concerns that an individual could be identified. Retirement plan information contains employee and employer (if applicable) contribution rates to all available retirement savings plans each year; recall that this includes contribution rates to both the mandatory plan and the voluntary TDA. Demographics information includes employee gender, age collapsed into bins due to confidentiality concerns, marital status (which, for reasons discussed later, is imperfectly observed), hiring year, and category of employment (faculty versus staff). To control for macroeconomic conditions, I also include publicly available variables, such as the annual inflation rate and monthly returns on the Standard & Poor 500 index. I use official announcement from the national bureau of economic research to determine the time of the Great Recession. It started in December 2007 and ended in June 2009.

As noted, the annual earnings of employees are collapsed into bins to address confidentiality concerns. However, in regressions it is not desirable to use earnings bands rather than earnings amount because using binned income does not capture the true variance of the effect of income on outcome variables. Therefore, I impute the earnings amount using publicly available data on the distribution of annual earnings among all employees in this public university in a single year, and I draw randomly from the appropriate band in the publicly available data. I assume that the distribution of earnings bins not included in the public record is uniform. Figure 1.2, which compares the distribution of imputed annual earnings (the solid curve) to earnings distribution from the public record (the dashed curve), shows that the distribution of imputed earnings is close to the distribution of annual income in the publicly available data.

The initial panel data contain 1,525,269 observations representing 21,961 employees over 14 years. I exclude observations that include an unusual payment event, such as an arrears payment, in any retirement savings plan.[6] I also remove observations with an annual income of less than $10,000 because these observations probably represent employees who worked at the university for a very short period of time. Recall that in the first chapter of my dissertation, I mentioned that on or after June 2010, the university had undergone another policy change on its mandatory DC retirement plan for newly hired faculty. To eliminate the potential impact of this policy change, I exclude employees hired on or after June 2010. The final sample contains 1,061,622 observations representing 11,186 employees. Among these, 844,385 observations are made on 8,143 employees who were hired before 2004 and 217,237 observations are made on 3,043 employees who were hired between January 2004 and June 2010. Here I focus on how new hires react to the Great Recession in the first two months of their employment, and I do so because new hires are more likely to pay attention to their pension choices, whereas existing employees may be reluctant to adjust their retirement accounts . To be thorough, I include at the end of this paper a brief discussion on existing employees.

[6] Arrears are a period when the employee should have contributed to the plan, but did not.

2.3.2 Descriptive Statistics

Table 2.1 uses the first month's data among employees who were hired between January 2004 and June 2010 to show information about employees hired before, during, and after the Great Recession. According to Table 2.1, employees hired before, during, and after the Great Recession are not particularly demographically distinctive. Figures **??**, 2.4, and 2.5 show how demographic variables evolve each year. Figure **??** shows the evolution of the fraction of female employees, full-time employees, and faculty. The blue line connected by filled circles represents the fraction of new female employees each year. The red line connected by triangles represents the fraction of new full-time employees each year. The green line connected by cross marks represents the fraction of new faculty hired each year. All of these fractions are very stable over time. The only exception occurred in 2010, when the fraction of faculty significantly dropped. This change can be attributed to the fact that I excluded all of the employees hired on or after June 2010, and the majority of the faculty are hired in July or August of each year.[7]

Figure 2.4 shows how the fraction of marital status evolved. The blue line connected by filled circles represents the fraction of new employees who in a given year are married. The red line connected by triangles represents the fraction of new employees who in a given year are single. The green line connected by cross marks represents the fraction of new employees who in a given year are neither married nor single. As in Figure **??**, these fractions remain quite stable over time.

Figure 2.5 shows the average wage and annual income (measured in thousands of 2018 dollars) from 2004 to 2010. The blue line connected by filled circles represents the

[7]Recall that I exclude employees hired on or after June 2010 because after this date policy changes were instituted in the university's mandatory DC plan.

average age among new employees each year, while the red line connected by triangles represents the average annual income measured in thousands of 2018 dollars each year. The average age among employees hired each year is stable. However, the average annual income spiked in 2009 and dropped significantly in 2010. The considerable decrease in 2010 reflects the fact that I excluded new hires after June 2010, and hence I excluded most of the faculty hired in 2010, whose average annual income is higher than the average annual salary of other employees in the university. The 2009 spike in average annual income is unexpected. Figure **??** shows the distribution of real income among new hires in 2008 using green bars and the distribution of real income among new hires in 2009 using transparent bars with black borders. The x-axis represents annual income measured in thousands of 2018 dollars while the y-axis is the density for each bin. According to Figure **??**, two factors caused the 2009 spike in average annual income. The most important of these is the rightward shift in distribution. The fraction of new hires with an annual income between \$20,000 and \$30,000 dropped significantly in 2009, while the fraction of new hires with an annual income higher than \$75,00 increased that same year. The two 2009 outliers also increased the average annual income. The spike in average annual income in 2009 still exists after I exclude observations that have an annual income higher than \$200,000. The best explanation is suggested by Figure 2.7: the university hired fewer employees in 2009. If the total amount of funding that can be allocated to new employees did not change very much in 2009, the average annual income in 2009 would spike.

From Table 2.1, which compares the mandatory DC plan participation rate among new hires made in different periods, it is evident that new hires made during the Great Recession preferred the DB plan over the DC plan, whereas new hires made during other periods preferred the DC plan. Employee responses to the voluntary TDA, however, show a different pattern. The average participation rate for the voluntary TDA increased over time while the average contribution rate decreased. Table 2.1 suggests that faculty hired during the Great Recession chose the mandatory DB plan over the mandatory DC plan. Since the Great Recession, all employees have been more likely to own a voluntary TDA but they are contributing less money to their accounts. A concern raised by the summary statistics table is whether the changes that I observe in the table reflect a change in hiring practices during the Great Recession. In other words, did the university hire fewer employees? Figure 2.7 shows the number of newly hired female employees, full time employees, and faculty each year. The graph suggests that after 2008, the university did hire fewer employees. [8] To address this concern, I include in my regression the number of faculty and the number of staff hired each year.

2.3.3 Graphical Evidence

Before examining the empirical results, I present some graphical evidence of how employees reacted to the Great Recession. Any evidence presented in this subsection should be interpreted as a correlation rather than a causal effect. Figure 2.8 plots the average mandatory DC plan participation rate, the average voluntary TDA participation rate, and the annual return from the S&P 500 index. The blue line connected by filled circles represents the participation rate for the mandatory DC plan each year. The red line connected by triangles represents the participation rate for the voluntary TDA each year. The green line connected by cross marks represents the annual S&P

[8] The drop in 2010 should be ignored because the data ends on June 2010.

500 return rate each year. From Figure 2.8, it is clear that the participation rate for the mandatory DC plan moved in the same direction as the annual S&P 500 return. The participation rate for the voluntary TDA plan, however, was stable during this period and it is difficult to determine whether there is any correlation between the annual S&P 500 return rate and the voluntary TDA plan participation rate. In Figure 2.9, the blue line connected with filled circles plots the average contribution rate to the voluntary TDA plan by year while the red line connected with cross marks the annual return from the S&P 500 index. According to Figure 2.9, the average contribution rate to the voluntary TDA plan is positively related to the annual S&P 500 return.

In the next two sections, I present empirical specifications and main results that quantify newly hired employees' responses to the Great Recession. I focus on new hires instead of existing hires because new hires need to set up their retirement accounts, and, thus, they pay more attention to their participation and contribution decisions. Existing hires, in contrast, may not pay close attention to their retirement accounts.

2.4 Empirical Strategy

This paper investigates whether the Great Recession induced any change in participation decision regarding the mandatory DC plan and participation and contribution decisions regarding the voluntary TDA. I present two sets of empirical strategies. The first follows an event study specification that uses indicators based on hiring date to estimate the effect of the Great Recession. The second set of empirical strategies directly uses the monthly S&P 500 return as the key right-hand variable.

2.4.1 Event Study

The first specification investigates whether faculty changed their the mandatory DC plan participation decisions due to the Great Recession. Recall that only faculty can choose between the DC and DB plan; all other employees must choose the DB plan as their mandatory retirement plan. I first use observations made in the month that new faculty are employed to estimate equation 2.1. The goal of this equation is to study the effect of the Great Recession on new faculty mandatory plan choices by following an event study specification. Then I re-estimate this equation using observations made two months after their employment began to address the concern that faculty can wait up to 60 days to make their choice between the DC and the DB plan for their mandatory retirement savings package.

$$
\begin{aligned}
\mathbb{1}(DC_{Mandatory})_{it} = {} & \beta_0 + \beta_1 \text{Pre}_i + \beta_2 \text{After}_i + \beta_3 \text{Female}_i + \beta_4 \text{Full Time}_{it} + \beta_5 \text{Income}_{it} \\
& + \beta_6 \text{Married}_{it} + \beta_7 \text{Single}_{it} + \beta_8 \text{NumFaculty}_t \\
& + \sum_j \beta_j \text{Age Bin}_j + \epsilon_{it}.
\end{aligned} \tag{2.1}
$$

Pre_i takes a value of one if the faculty is hired before December 2007, the starting date of the Great Recession. After_i takes a value of one if the faculty is hired after June 2009, the ending date of the Great Recession. Full Time_{it} is an indicator that takes a value of one if the faculty is hired as a full-time employee. Income_{it} is the imputed annual income for the employee measured in thousands of 2018 dollars. Married_{it} and Single_{it} are indicators for the faculty who are married and single, respectively. The omitted category for marital status is all other marital statuses, including divorced, living together, widowed, and unknown.[9] NumFaculty$_t$ is the number of new faculty hired each year. This variable addresses the concern that any changes in the outcome variables I observe could be driven by the hiring fluctuations during the Great Recession.[10] Age Bin are indicators for different age bins and the reference category of age bins is those who were aged below 30.[11] ϵ_{it} is assumed to have a conditional mean of zero.

The coefficients of interest are β_1 and β_2. β_1 shows how the probability of choosing the mandatory DC plan among faculty hired before the Great Recession differs from the probability of choosing the mandatory DC plan among faculty hired during the Great Recession. Similarly, β_2 shows the difference in such a probability between faculty hired after the Great Recession and faculty hired during the Great Recession.

Equation 2.1 is a linear probability model. I also present the estimation results using a probit model. The specification I use is

$$\mathbb{1}(DC_{Mandatory})_{it} = \begin{cases} 1 & \text{if } X^T\beta + u_{it} > 0 \\ 0 & \text{Otherwise} \end{cases}, \tag{2.2}$$

where X includes all the covariates used in equation 2.1 and u_{it} is assumed to follow the standard normal distribution with mean zero and variance one.

Next I turn my attention to the effect of the Great Recession on voluntary TDA participation and contribution decisions among faculty and other employees. I esti-

[9]Marital status can be unknown because the university does not require employees to report their marital status.

[10]For example, suppose that the outcome variable is voluntary TDA plan participation. The concern here is that someone may believe that the number of faculty who participate the voluntary TDA plan does not change – i.e., changes in the participation rate are due only to the change in the number of faculty hired in each year.

[11]Recall that for privacy concerns, age in the data is collapsed into age bins.

mate the following specification using data on faculty and data on other employees separately.

$$\begin{aligned} y_{it} = {} & \beta_0 + \beta_1 \text{Pre}_i + \beta_2 \text{After}_i + \beta_3 \text{Female}_i + \beta_4 \text{Full Time}_{it} + \beta_5 \text{Income}_{it} \\ & + \beta_6 \text{Married}_{it} + \beta_7 \text{Single}_{it} + \beta_8 \text{NumFaculty}_t \\ & + \sum_j \beta_j \text{Age Bin}_j + \epsilon_{it}. \end{aligned} \tag{2.3}$$

All the covariates in equation 2.3 share the same definition as in equation 2.1. ϵ_{it} is assumed to have a conditional mean of zero. In addition, when I'm estimating equation 2.3 among other employees, I replace NumFaculty_t with NumOther_t, which represents the number of non-faculty hired each year. I run the regression above on two outcome variables: an indicator of owning a voluntary TDA and the contribution rate to a voluntary TDA. I also estimate the voluntary TDA participation rate using a probit model and the voluntary TDA contribution rate using a tobit model specified below, wherein the contribution rate is left censored at zero.

$$\text{TDA Contribution}_{it} = \begin{cases} \text{TDA Contribution}^*_{it} & \text{if } X^T\beta + u_{it} > 0 \\ 0 \quad \text{Otherwise} \end{cases}, \tag{2.4}$$

where X includes all the covariates used in equation 2.3 and u_{it} is assumed to follow a normal distribution with mean zero.

The identification assumption of both specifications is that new employees hired before, during, and after the Great Recession do not differ systematically in their saving preferences. Figures **??**, 2.4, and 2.5 show that employees do not differ much in terms of observables, and there is no reason to believe that employees would differ much in terms of unobservables. However, if newly hired employees do differ systematically in some unobservables that lead to different saving preferences, then estimation results will be biased. The direction of bias depends on how unobservables correlate with outcome variables.

2.4.2 Changes in Stock Market Return

The specifications 2.1 and 2.3 follow an event study design to see how newly hired employees respond to the Great Recession. It is also important to know how they respond to changes in stock market returns in general given that employees do not experience significant changes in stock returns every day. Specifications below mimic the two specifications in the event study section but use the monthly return rate from the S&P 500 index as the key right hand variable. The monthly return rate is calculated as if someone purchased the S&P 500 index on the first day of the previous month and sold the index on the first day of the current month. This return rate reflects the most recent return information an individual could obtain. [12] I estimate equation 2.5 using observations made on newly hired faculty before June 2010 with three different outcome variables: choosing the DC plan as their mandatory retirement savings plan; owning a voluntary TDA; and the contribution rate to the voluntary TDA. Then I estimate the equation twice: first using data on faculty, and then using data on non-faculty, in each case with two outcome variables: owning a

[12] Because the administrative records are recorded monthly, it does not make sense to use daily stock market return.

voluntary TDA and the contribution rate to the voluntary TDA.

$$\begin{aligned} y_{it} = \beta_0 &+ \beta_1 \text{Stock Return Rate}_t + \beta_2 \text{Female}_i + \beta_3 \text{Full Time}_{it} + \beta_4 \text{Income}_{it} \\ &+ \beta_5 \text{Married}_{it} + \beta_6 \text{Single}_{it} + \beta_7 \text{NumFaculty}_t \\ &+ \sum_j \beta_j \text{Age Bin}_j + \epsilon_{it}. \end{aligned} \tag{2.5}$$

Last, I include two sets of extra control variables in equation 2.5. Specification 2.6 adds two dummy variables to indicate whether the new employees are hired before or after the Great Recession. These two dummy variables captures all of the time invariant effects from factors other than the stock market before and after the Great Recession. Then β_1 captures the effect of stock market returns on my outcome variables, net of all other time fixed effects. Specification 2.7 includes as an additional control variable: the monthly national unemployment rate.

$$\begin{aligned} y_{it} = \beta_0 &+ \beta_1 \text{Stock Return Rate}_t + \beta_2 \text{Pre}_i + \beta_3 \text{After}_i + \beta_4 \text{Female}_i + \beta_5 \text{Full Time}_{it} \\ &+ \beta_6 \text{Income}_{it} + \beta_7 \text{Married}_{it} + \beta_8 \text{Single}_{it} + \beta_9 \text{NumFaculty}_t \\ &+ \sum_j \beta_j \text{Age Bin}_j + \epsilon_{it}. \end{aligned} \tag{2.6}$$

$$\begin{aligned} y_{it} = \beta_0 &+ \beta_1 \text{Stock Return Rate}_t + \beta_2 \text{Unemployment Rate}_i + \beta_3 \text{Female}_i \\ &+ \beta_4 \text{Full Time}_{it} + \beta_5 \text{Income}_{it} + \beta_6 \text{Married}_{it} + \beta_7 \text{Single}_{it} + \beta_8 \text{NumFaculty}_t \\ &+ \sum_j \beta_j \text{Age Bin}_j + \epsilon_{it}. \end{aligned} \tag{2.7}$$

2.5 Results

2.5.1 Great Recession

In this subsection, I present the effect of the Great Recession estimated using specification 2.1 to specification 2.4, as described in section 2.4.1. Table 2.2 shows the effect of the Great Recession on the probability that new faculty will choose the DC plan rather than the DB plan as their mandatory retirement savings plan. Table 2.3 and Table 2.4 show the effect of the Great Recession on voluntary TDA plan participation among faculty and other employees, respectively. Table 2.5 shows the effect of the Great Recession on voluntary TDA plan contribution rate among faculty, while Table 2.6 looks at the same outcome variable using observations for other employees.

In each table, Panel A shows the regression results using a linear model. Columns 1 and 3 of Panel A show the regression results when I only include the key right hand side variable, which represents the results I would get if, following Bricker *et al.* (2011); Hurd & Rohwedder (2010, 2012); Coronado & Dynan (2012), I compared the mean of the outcome variable among new employees hired before, during, and after the Great Recession. Columns 2 and 4 of Panel A show the regression results using the full specification. Then in Panel B, I present the regression results using either a probit or tobit model with full sets of covariates.

On the Mandatory plan side, the first two columns of Table 2.2 show the estimation results of equation 2.1 using observations made during the first month that faculty joined this public university, while the last two columns show the regression results using observations made during the third month after faculty started to work.

Regardless of which set of observations I use, the estimation results are qualitatively similar: compared to new faculty hired during the Great Recession, new faculty hired before the Great Recession are more likely to choose the DC plan rather than the DB plan as their mandatory retirement savings plan, while new faculty hired after the Great Recession are not statistically different from new faculty hired during the Great Recession. As indicated in the first month's data, faculty who were hired before the Great Recession are 11.8 percentage points more likely to choose the DC plan as their mandatory retirement savings package than faculty who were hired during the Great Recession. The estimates are statistically significant at the 1% level. These estimates imply that the mandatory DC plan participation rate among new faculty reached its maximum before the Great Recession, and then decreased and became flat during and after the Great Recession.

On the voluntary plan side, Table 2.3 shows the estimation of specification 2.3 when the outcome variable is an indicator of owning a voluntary TDA using data on faculty; Table 2.4 shows the results using data on other employees. Under the full specification (column 2 and column 4), both the linear probability model and the probit model indicate that, compared to employees hired during the Great Recession, employees (both faculty and other employees) were less likely to own a voluntary TDA prior the Great Recession. However, the probability of owning a voluntary TDA among employees hired after the Great Recession is not statistically different from the probability among employees hired during the Great Recession. For example, examining the first month data we see that faculty hired before the Great Recession are 9.56 percentage points less likely to own a voluntary TDA than faculty hired during the Great Recession. This difference is statistically significant at the 1% level. On the other hand, faculty hired after the Great Recession are 11.9 percentage points more likely to own a voluntary TDA than faculty hired during the Great Recession, but this estimates is not statistically significant.

Table 2.5 shows the estimation of specification 2.3 when the outcome variable is the voluntary TDA contribution rate among faculty. Using the linear model to examine the first month data among faculty shows that faculty hired before the Great Recession contribute 1.91 percentage points more to the voluntary TDA than faculty hired during the Great Recession. The average contribution rate among faculty hired after the Great Recession, however, does not differ statistically from the average the average contribution rate among faculty hired during the Great Recession. Estimation results under the tobit model are qualitatively similar to the results under the linear model when the first month data is used. Both models suggests that the average contribution rate to the voluntary TDA are higher among faculty hired before and after the Great Recession. In a single exception, the average contribution rate among faculty hired before the Great Recession is no longer statistically different from the average contribution rate among faculty hired during the Great Recession. However, when the third month data are examined, OLS and tobit show opposite signs in the average contribution rate among faculty hired before the Great Recession. OLS suggests that the average contribution rate among faculty hired before the Great Recession is 1.73 percentage points higher than the average contribution rate among faculty hired during the Great Recession; the tobit model suggests that the difference in the average contribution rate is -1.77 percentage points. I acknowledge that I cannot explain why this is the case.

Table 2.6 shows the results using staff data. Estimation results suggest that staff behave differently than faculty. Both the linear model and the tobit model show that staff hired before the Great Recession contribute less to their TDAs than staff hired during the Great Recession. The average contribution rate among staff hired after the Great Recession is not statistically different from the average contribution rate among staff hired during the Great Recession.

Table 2.7 summarizes the main results presented so far. Panel A of Table 2.7 summarizes the regression results using OLS. When the outcome variable is either the mandatory DC plan participation rate or the voluntary TDA participation rate, Panel B of Table 2.7 shows the main results under the probit model, whereas when the outcome variable is the contribution rate, Panel B shows the results under the tobit model. During the Great Recession, faculty were less likely to choose the mandatory DC plan, more likely to own TDAs, and contributed less to TDAs. Staff, on the other hand, were more likely to own TDAs and contributed more to their TDAs. Given that the mandatory DC plan and the TDAs are both DC plans, the fact that faculty reacted differently to the two plans is puzzling. Moreover, although both staff and faculty were more likely to own TDAs during the Great Recession, it is not clear why faculty were decreasing their contribution rate at the same time that staff were increasing their contribution rate. One explanation is that employees wanted to control the level of risk assumed in their retirement savings while they simultaneously attempted to hold their investment return rate constant. In this case, faculty first chose the mandatory DB plan over the mandatory DC plan because the DB plan does not involve any risk and, therefore, it provides a lower return rate. To compensate for this decrease in the return rate, faculty opened TDAs to expose themselves into the stock market. Because the stock market is crashing, they did not want to put too much money into their accounts. One flaw with this explanation is that it does not explain why staff increased their contribution rate during the Great Recession.

2.5.2 Changes in Stock Market Return

In this subsection, I present the effect of the Great Recession using the monthly S&P 500 return rate as the key right hand side variable. Table 2.8 looks at how the stock market return rate affects the probability that new faculty would choose the DC plan instead of the DB plan as their mandatory retirement savings plan. Table 2.3 and Table 2.4 looks at how the stock market return rate is related to voluntary TDA plan participation rate among faculty and other employees, respectively. Table 2.5 shows the effect of the stock market return rate on the voluntary TDA plan contribution rate among faculty, while Table 2.6 looks at the same outcome variable using observations for other employees.

The first two columns of panel A on each table show the regression results using OLS, whereas the last two columns of panel A show the estimation results under either a probit model or a tobit model, depending on the outcome variable discussed. Columns 1 and 3 of each table use observations made during the first month that employees started to work, while columns 2 and 4 use the third month data to address the possibility that employees can wait up to 60 days to make their pension choices. The first two columns of panel B on each table show the estimation results of specification 2.6, and the last two columns of panel B show the estimation results of specification 2.7. Recall that both specifications are OLS specification with additional control variables.

Table 2.8 shows that the mandatory DC plan participation rate is positively related to the stock market return. It implies that the mandatory DC plan participation rate reached its minimum during the Great Recession. Table 2.9 and Table 2.10 indicate that the voluntary TDA participation rate is negatively related to the stock market return. These results are in line with regression results shown in Table 2.2, 2.3 and 2.4. Table 2.11 shows that increase in the stock market return lead to increase in the average contribution rate to voluntary TDA among faculty. However Table 2.12 shows that the effect of the stock market return on the average contribution rate to the voluntary TDA among staff depends on the month of the data I use.

Table 2.13 summarizes key results from these five tables by outcome variable.

2.6 Robustness Check

In this section, I present two robustness checks of my results. First, I examine whether my estimates are sensitive to the periods used in the analysis. In the previous section, my results used data from 2004 to 2010. However, it is possible that I included too many observations from before the Great Recession, which would bias my estimates. Therefore, in this section, I re-estimate equations 2.1, 2.3, and 2.5 using new hires between 2007 and 2010 – a period that includes new employees hired one year before the Great Recession, the year of the Recession, and a year after the Recession. The second robustness check concerns whether my estimates only apply to new employees. Here I estimate the effect of the stock market return among employees hired before January 2004.

2.6.1 New Employees between 2007 and 2010

In this subsection, to have the same number of years before and after the Great Recession, I exclude new employees hired before 2007. Recall that my specification is

$$\begin{aligned} y_{it} &= \beta_1 \text{Pre}_i + \beta_2 \text{After}_i + \beta_3 \text{Female}_i + \beta_4 \text{Full Time}_{it} + \beta_5 \text{Income}_{it} \\ &+ \beta_6 \text{Married}_{it} + \beta_7 \text{Single}_{it} + \sum_j \beta_j \text{Age Band}_j + \epsilon_{it}. \end{aligned}$$

Table 2.14 through Table 2.16 show the estimation result. Those results are qualitatively similar to the estimation results produced from the full sample. Mandatory DC participation is positively related to the stock market return rate. For every percentage point increase in the stock market return rate, mandatory DC plan participation increases by 0.9 percentage points. The voluntary TDA participation rate is negatively related to the stock market return rate. While the stock market returns positively affect the voluntary TDA contribution rate among faculty, the former has little impact on the average voluntary TDA contribution rate among other employees.

2.6.2 Existing Employees

Next I change my focus to employees who were hired before January 2004. Because employees make their irrevocable decision about the mandatory plan when they join this public university, how existing employees' mandatory plan choices differ before and after the Great Recession does not matter. Thus, I estimate equation 2.5 among existing employees. Recall that in the main results section, I exclude new hires made on or after June 2010 to avoid the potential impact of policy changes on the mandatory DC plan. However, workers who were hired before 2004 are not subject to this policy change. Therefore, I extend the sample to include observations made about existing employees beyond June 2010. The extended sample contains 844,385 observations made about 8,143 employees hired before January 2004. Table 2.17 shows the estimation results with standard errors clustered at the individual level. Last, I exploit the panel nature of the data and estimate a fixed effect model with the following specification

$$\begin{aligned} y_{it} = \beta_0 + \beta_1 \text{Stock Return Rate}_t + \beta_2 \text{Full Time}_{it} + \beta_3 \text{Income}_{it} \\ + \beta_4 \text{Married}_{it} + \beta_5 \text{Single}_{it} + \sum_j \beta_j \text{Age Band}_j + \alpha_i + \epsilon_{it}. \end{aligned}$$

In contrast to equation 2.5, this specification excludes gender as the control variable because it is part of the individual fixed effect.

According to Table 2.17, existing employees act differently from new employees. Both the voluntary TDA participation rate and the voluntary TDA contribution rate are positively related to the stock market return rate among existing faculty. However the stock market return rate has little impact on these two outcomes among existing staff.

2.7 Conclusion

In this paper, I assume that the decrease in the stock market return during the Great Recession was independent of other factors that can alter individual retirement savings choices, and I investigate whether this drop in the stock market return had any impact on the mandatory and voluntary TDA choices made by employees working at a large public university. I first conduct an event study that uses novel panel data on retirement plan contributions of employees at a public university. With regard to the mandatory plan, I find that compared to new faculty hired before the Great Recession, those hired during the Great Recession are 11.8 percentage points less likely to choose the DC plan as their mandatory retirement savings plan. With regards to the voluntary TDA, I find that compared to new faculty hired before the Great Recession, those hired during the Great Recession are 9.56 percentage points more likely to own a TDA, but they contribute 1.91 percentage points less to it. All three estimates are statistically significant at the 1% level. Compared to new staff hired before the Great Recession, those hired during the Great Recession are 9.59 percentage points more likely to own a voluntary TDA (statistically significant at the 1% level) and contribute 0.41 percentage points more to the voluntary TDA (statistically significant at the 5% level). However, new employees, including both faculty and staff, hired after the Great Recession are not statistically different from the new employees hired during the Great Recession.

I then extend my analysis to see how new employees generally respond to stock market changes. I find that for every percentage point increase in the monthly return rate of S&P 500 index, the probability that new faculty choose the DC plan as their mandatory retirement savings plan increases by 0.99 percentage points. For every percentage point increase in the monthly return rate of S&P 500 index, new faculty are 0.56 percentage points less likely to own a voluntary TDA , but they contribute 0.16 percentage points more to their accounts. In contrast, new staff are 0.23 percentage points less likely to own a TDA and contribute 0.03 percentage points less to their accounts. All estimates among faculty are statistically significant at the 10% level, while none of the estimates among staff are statistically significant.

Finally, I conduct a similar analysis among employees hired before January 2004.

My regression results indicate that for every percentage point increase in the stock market return rate, existing faculty are 0.16 percentage points more likely to own a voluntary TDA, and they contribute 0.03 percentage points more to the voluntary TDA; existing staff are 0.006 percentage points less likely to own a voluntary TDA, and they contribute 0.0002 percentage points less to the voluntary TDA. Only the estimate of the voluntary TDA contribution among faculty is statistically significant at the 5% level. All other estimates are not statistically significant at all.

In addition, I demonstrate that through their TDA choices faculty and staff reacted differently to the Great Recession. Given that the mandatory DC plan and the voluntary TDA are both DC plans, it is not clear why faculty reacted differently for the two plans. Moreover, although both staff and faculty are more likely to own TDAs during the Great Recession, it is not clear why faculty decreased their contribution rate while staff simultaneously increased their contribution rate.

Table 2.1: Summary statistics using the first month data

Panel A: before the Great Recession

	All new hires				New faculty only			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Female	48.3%	49.98%	0	1	41.4%	49.29%	0	1
Age	38.44	9.41	27.5	77.75	39.46	9.18	27.5	67.75
Fulltime	97.2%	16.36%	0	1	96.3%	18.77%	0	1
Faculty	44.4%	49.69%	0	1				
Married	27.2%	44.52%	0	1	44.0%	49.66%	0	1
Single	21.5%	41.07%	0	1	22.7%	41.91%	0	1
Other Marital Statuses	51.3%	50.00%	0	1	33.3%	47.17%	0	1
Imputed Income (real 2018 dollar) in'000	57.46	42.87	15.27	476.97	86.58	47.04	25.70	376.42
Voluntary TDA Participation	**24.1%**	42.77%	0	1	**44.1%**	49.68%	0	1
Voluntary TDA Contribution	**2.37**	8.47	0	90.6	**4.63**	11.74	0	90.6
Mandatory DC Participation					**67.1%**	47.01%	0	1
N	2,035				903			

Panel B: during the Great Recession

	All new hires				New faculty only			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Female	47.8%	49.99%	0	1	44.2%	49.76%	0	1
Age	38.19	9.44	27.5	67.75	39.74	8.87	27.5	67.75
Fulltime	96.5%	18.29%	0	1	95.9%	19.84%	0	1
Faculty	38.8%	48.76%	0	1				
Married	26.7%	44.25%	0	1	42.8%	49.56%	0	1
Single	15.7%	36.41%	0	1	22.3%	41.71%	0	1
Other Marital Statuses	57.6%	49.45%	0	1	34.9%	47.77%	0	1
Imputed Income (real 2018 dollar) in'000	54.58	58.38	13.16	790.48	84.90	69.17	21.00	606.56
Voluntary TDA Participation	**31.8%**	46.62%	0	1	**53.2%**	49.99%	0	1
Voluntary TDA Contribution	**1.65**	5.20	0	77.4	**2.73**	7.09	0	77.4
Mandatory DC Participation					**55.0%**	49.84%	0	1
N	694				269			

Panel C: after the Great Recession

	All new hires				New faculty only			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Female	41.4%	49.33%	0	1	35.2%	47.95%	0	1
Age	37.09	8.73	27.5	63.5	37.49	7.53	27.5	63.5
Fulltime	97.8%	14.79%	0	1	96.8%	17.67%	0	1
Faculty	39.8%	49.03%	0	1				
Married	27.4%	44.67%	0	1	43.2%	49.73%	0	1
Single	17.2%	37.80%	0	1	22.4%	41.86%	0	1
Other Marital Statuses	55.4%	49.79%	0	1	34.4%	47.70%	0	1
Imputed Income (real 2018 dollar) in'000	63.43	59.40	16.60	707.60	90.68	72.30	32.80	707.60
Voluntary TDA Participation	**32.2%**	46.79%	0	1	**51.2%**	50.19%	0	1
Voluntary TDA Contribution	**1.35**	4.61	0	63	**2.66**	6.89	0	63
Mandatory DC Participation					**67.2%**	47.14%	0	1
N	314				125			

Note: New hires (faculty) during the Great Recession are defined as employees (faculty) who were hired between December 2007 and June 2009. Voluntary Tax Deferred Accounts (TDA) include both the 403(b) plan and the 457 plan. The TDA contribution is measured as the percentage point of the employee's pretax income. The mandatory DC participation rate is only available for faculty because other employees cannot choose the DC plan.

Table 2.2: The effect of the Great Recession on mandatory DC plan participation for faculty

Panel A: linear probability model

	First month data				Third month data			
	1		2		3		4	
Mandatory DC Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	0.121***	(0.0342)	0.118***	(0.0343)	0.0969***	(0.0269)	0.0925***	(0.0269)
After the Great Recession	0.122**	(0.0519)	-0.00490	(0.0809)	0.0700*	(0.0398)	0.0662	(0.0610)
Female			-0.0676**	(0.0276)			-0.0219	(0.0199)
Fulltime			-0.151**	(0.0638)			0.0504	(0.0589)
Income in '000s			0.000931***	(0.000249)			0.000202	(0.000224)
Number of faculty			-0.000948	(0.000598)			0.0000933	(0.000464)
Married			0.0359	(0.0305)			-0.0186	(0.0218)
Single			0.00527	(0.0366)			0.00441	(0.0251)
Age Bins			Yes				Yes	
N	1,297				1,291			
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: probit model

	First month data		Third month data	
Mandatory DC Participation	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	0.317***	(0.0900)	0.395***	(0.104)
After the Great Recession	-0.0207	(0.222)	0.260	(0.254)
Female	-0.184**	(0.0754)	-0.107	(0.0929)
Fulltime	-0.443**	(0.205)	0.172	(0.216)
Income in '000s	0.00279***	(0.000845)	0.00100	(0.00108)
Number of faculty	-0.00257	(0.00167)	0.000426	(0.00183)
Married	0.0995	(0.0839)	-0.0808	(0.101)
Single	0.0188	(0.0997)	0.0207	(0.127)
Age Bins	Yes			
N	1,297		1,291	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$				

Note: Panel A assumes a linear model. The regression results in columns 1 and 2 of panel A are estimated using observations made on the first month that employees started to work. Results in columns 3 and 4 of Panel A are estimated using observations made on the third month that employees started to work. Panel B estimates a probit model. Column 1 of panel B shows the results using the first month data, and column 2 shows the results using the third month data. The variable "Before the Great Recession" takes a value of one for employees hired before December 2007, the starting date of the Great Recession. The variable "After the Great Recession" takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty is the number of new faculty hired each year. The reference category of marital status consists of all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not report their marital status.

Table 2.3: The effect of the Great Recession on TDA participation for faculty

Panel A: linear probability model

	First month data				Third month data			
	1		2		3		4	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	-0.0908***	(0.0347)	-0.0956***	(0.0346)	-0.314***	(0.0210)	-0.317***	(0.0216)
After the Great Recession	-0.0196	(0.0541)	0.119	(0.0859)	-0.0943***	(0.0347)	0.0159	(0.0605)
Female			-0.000846	(0.0286)			0.0478*	(0.0247)
Fulltime			-0.124*	(0.0737)			-0.113**	(0.0562)
Income in ’000s			0.000680**	(0.000274)			0.000866***	(0.000256)
Number of faculty			0.00138**	(0.000627)			0.00105**	(0.000448)
Married			0.0453	(0.0318)			0.0300	(0.0273)
Single			-0.0287	(0.0380)			-0.00757	(0.0339)
Age Bins			Yes				Yes	
N	1,297				1,291			
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: probit model

	First month data		Third month data	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	-0.246***	(0.0886)	-1.343***	(0.141)
After the Great Recession	0.308	(0.221)	-0.128	(0.271)
Female	-0.00193	(0.0734)	0.162*	(0.0836)
Fulltime	-0.319*	(0.191)	-0.432*	(0.240)
Income in ’000s	0.00179**	(0.000729)	0.00325***	(0.00109)
Number of faculty	0.00356**	(0.00163)	0.00432**	(0.00168)
Married	0.119	(0.0815)	0.121	(0.0914)
Single	-0.0722	(0.0979)	-0.0110	(0.111)
Age Bins	Yes			
N	1,297		1,291	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$				

Note: Panel A assumes a linear model. The regression results in columns 1 and 2 of panel A are estimated using observations made on the first month that employees started to work. Results in columns 3 and 4 of Panel A are estimated using observations made on the third month that employees started to work. Panel B estimates a probit model. Column 1 of panel B shows the results using the first month data, and column 2 shows the results using the third month data. The variable “Before the Great Recession” takes a value of one for employees hired before December 2007, the starting date of the Great Recession. The variable “After the Great Recession” takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty is the number of new faculty hired each year. The reference category of marital status consists of all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not report their marital status.

Table 2.4: The effect of the Great Recession on TDA participation for other employees

Panel A: linear probability model

	First month data				Third month data			
	1		2		3		4	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	-0.102***	(0.0205)	-0.0959***	(0.0201)	-0.530***	(0.0241)	-0.531***	(0.0242)
After the Great Recession	0.0122	(0.0345)	-0.0339	(0.0518)	-0.0157	(0.0376)	0.0359	(0.0566)
Female			0.00314	(0.0154)			0.00478	(0.0205)
Fulltime			0.0167	(0.0501)			0.0469	(0.0752)
Income in '000s			0.00167*	(0.000961)			0.00112	(0.00110)
Number of staff			-0.000228	(0.000233)			0.000447*	(0.000270)
Married			-0.0158	(0.0231)			0.0514*	(0.0297)
Single			-0.0478***	(0.0164)			-0.0155	(0.0262)
Age Bins			Yes				Yes	
N	1,746							
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: probit model

	First month data		Third month data	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	-0.480***	(0.0907)	-1.475***	(0.0808)
After the Great Recession	-0.100	(0.199)	0.124	(0.172)
Female	0.0198	(0.0833)	0.0183	(0.0675)
Fulltime	0.113	(0.290)	0.162	(0.240)
Income in '000s	0.00456	(0.00280)	0.00287	(0.00319)
Number of faculty	-0.000830	(0.000966)	0.00138*	(0.000839)
Married	-0.0600	(0.117)	0.174*	(0.0954)
Single	-0.315**	(0.127)	-0.0508	(0.0889)
Age Bins	Yes			
N	1,742		1,745	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$				

Note: Panel A assumes a linear model. The regression results in columns 1 and 2 of panel A are estimated using observations made on the first month that employees started to work. Results in columns 3 and 4 of Panel A are estimated using observations made on the third month that employees started to work. Panel B estimates a probit model. Column 1 of panel B shows the results using the first month data, and column 2 shows the results using the third month data. The variable "Before the Great Recession" takes a value of one for employees hired before December 2007, the starting date of the Great Recession. The variable "After the Great Recession" takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of staff is the number of new staff hired each year. The reference category of marital status consists of all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not report their marital status.

Table 2.5: The effect of the Great Recession on TDA contributions for faculty

Panel A: linear model

	First month data				Third month data			
	1		2		3		4	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	1.895***	(0.582)	1.907***	(0.594)	1.740***	(0.664)	1.726**	(0.679)
After the Great Recession	-0.0723	(0.751)	1.221	(1.325)	0.865	(1.220)	3.130*	(1.858)
Female			-0.327	(0.612)			-0.701	(0.668)
Fulltime			-1.689	(1.969)			-2.911	(2.309)
Income in '000s			0.00482	(0.00499)			0.0154**	(0.00691)
Number of faculty			0.0100	(0.00945)			0.0185*	(0.00985)
Married			0.322	(0.701)			-0.0796	(0.736)
Single			-0.711	(0.716)			0.0468	(0.861)
Age Bins			Yes				Yes	
N	1,297				1,291			
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: tobit model

	First month data		Third month data	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	0.568	(1.177)	-1.769**	(0.814)
After the Great Recession	4.222	(3.037)	3.586	(2.211)
Female	-0.462	(1.155)	-0.196	(0.869)
Fulltime	-4.399	(3.030)	-4.367	(2.720)
Income in '000s	0.0203**	(0.00995)	0.0275***	(0.00913)
Number of faculty	0.0426*	(0.0229)	0.0320**	(0.0131)
Married	1.280	(1.295)	0.226	(0.962)
Single	-1.536	(1.492)	-0.00986	(1.149)
Age Bins	Yes			
N	1,297		1,291	
N(Uncensored)	605		930	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$				

Note: Panel A assumes a linear model. The regression results in columns 1 and 2 of panel A are estimated using observations made on the first month that employees started to work. Results in columns 3 and 4 of Panel A are estimated using observations made on the third month that employees started to work. Panel B estimates a tobit model. Column 1 of panel B shows the results using the first month data, and column 2 shows the results using the third month data. The variable "Before the Great Recession" takes a value of one for employees hired before December 2007, the starting date of the Great Recession. The variable "After the Great Recession" takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty is the number of new faculty hired each year. The reference category of marital status consists of all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not report their marital status.

Table 2.6: The effect of the Great Recession on TDA contributions for other employees

Panel A: linear model

	First month data				Third month data			
	1		2		3		4	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	-0.407**	(0.192)	-0.408**	(0.191)	-0.922***	(0.279)	-0.857***	(0.288)
After the Great Recession	-0.483**	(0.194)	-0.557*	(0.309)	-0.665**	(0.332)	-0.520	(0.580)
Female			0.0425	(0.167)			0.194	(0.242)
Fulltime			-0.604	(0.717)			-0.755	(0.877)
Income in '000s			0.00854*	(0.00488)			0.0231*	(0.0141)
Number of staff			-0.000186	(0.00174)			0.00190	(0.00300)
Married			-0.149	(0.153)			0.560	(0.431)
Single			0.134	(0.283)			0.144	(0.345)
Age Bins			Yes				Yes	
N	1,746							
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: tobit model

	First month data		Third month data	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.
Before the Great Recession	-5.465***	(1.287)	-6.704***	(0.656)
After the Great Recession	-1.838	(2.245)	-0.268	(0.988)
Female	0.306	(1.087)	0.355	(0.516)
Fulltime	-0.484	(4.080)	-0.461	(1.874)
Income in '000s	0.0546*	(0.0299)	0.0379	(0.0242)
Number of faculty	-0.00672	(0.0114)	0.00584	(0.00525)
Married	-0.947	(1.415)	1.329*	(0.798)
Single	-2.402	(1.642)	-0.147	(0.764)
Age Bins	Yes			
N	1,746			
N(Uncensored)	207		736	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$				

Note: Panel A assumes a linear model. The regression results in columns 1 and 2 of panel A are estimated using observations made on the first month that employees started to work. Results in columns 3 and 4 of Panel A are estimated using observations made on the third month that employees started to work. Panel B estimates a tobit model. Column 1 of panel B shows the results using the first month data, and column 2 shows the results using the third month data. The variable "Before the Great Recession" takes a value of one for employees hired before December 2007, the starting date of the Great Recession. The variable "After the Great Recession" takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of staff is the number of new staff hired each year. The reference category of marital status consists of all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not report their marital status.

Table 2.7: Summary of the effect of the Great Recession

Panel A: linear model

		Faculty		Staff	
	Key right hand variable	First month data	Third month data	First month data	Third month data
Mandatory DC Plan	Before the Great Recession	0.118***	0.0925***	N/A	
	After the Great Recession	-0.00490	0.0662		
TDA Participation	Before the Great Recession	-0.0956***	-0.317***	-0.0959***	-0.531***
	After the Great Recession	0.119	0.0159	-0.0339	0.0359
TDA Contributions	Before the Great Recession	1.907***	1.726**	-0.408**	-0.857***
	After the Great Recession	1.221	3.130*	-0.557*	-0.520

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Panel B: probit/tobit model

		Faculty		Staff	
	Key right hand variable	First month data	Third month data	First month data	Third month data
Mandatory DC Plan	Before the Great Recession	0.317***	0.395***	N/A	
	After the Great Recession	-0.0207	0.260		
TDA Participation	Before the Great Recession	-0.246***	-1.343***	-0.480***	-1.475***
	After the Great Recession	0.308	-0.128	-0.100	0.124
TDA Contributions	Before the Great Recession	0.568	-1.769**	-5.465***	-6.704***
	After the Great Recession	4.222	3.586	-1.838	-0.268

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: Panel A summarizes OLS results on the mandatory DC plan participation, the TDA plan participation, and the TDA plan contributions under the full specification. Panel B summarizes probit results on the mandatory DC plan participation, the TDA plan participation, and tobit results on the TDA plan contributions under the full specification.

Table 2.8: The effect of stock market returns on mandatory DC participation for faculty

Panel A: main specifications

	OLS				Probit			
	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
Mandatory DC Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	0.990***	(0.297)	0.444*	(0.230)	2.672***	(0.792)	1.961**	(0.937)
Female	-0.0671**	(0.0277)	-0.0229	(0.0200)	-0.181**	(0.0755)	-0.110	(0.0926)
Fulltime	-0.154**	(0.0632)	0.0567	(0.0602)	-0.451**	(0.205)	0.208	(0.218)
Income in ’000s	0.000882***	(0.000255)	0.000199	(0.000222)	0.00270***	(0.000888)	0.00100	(0.00108)
Number of faculty	-0.0000984	(0.000347)	0.000285	(0.000270)	-0.000266	(0.000967)	0.00132	(0.00111)
Married	0.0386	(0.0304)	-0.0157	(0.0218)	0.104	(0.0837)	-0.0731	(0.101)
Single	0.00726	(0.0365)	0.00592	(0.0251)	0.0227	(0.0993)	0.0287	(0.127)
Age Bins	Yes							
N	1,297		1,291		1,297		1,291	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: OLS with additional control variables

	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
Mandatory DC Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	0.677*	(0.358)	0.0270	(0.269)	0.760**	(0.313)	0.213	(0.253)
Before the Great Recession	0.0775*	(0.0409)	0.0910***	(0.0311)				
After the Great Recession	-0.0544	(0.0863)	0.0658	(0.0611)				
Unemployment Rate					-4.304**	(1.922)	-2.837**	(1.294)
Female	-0.0679**	(0.0276)	-0.0219	(0.0199)	-0.0676**	(0.0276)	-0.0231	(0.0200)
Fulltime	-0.155**	(0.0629)	0.0507	(0.0589)	-0.155**	(0.0627)	0.0502	(0.0590)
Income in ’000s	0.000910***	(0.000251)	0.000201	(0.000224)	0.000909***	(0.000256)	0.000242	(0.000225)
Number of faculty	-0.000899	(0.000599)	0.000106	(0.000484)	-0.00162**	(0.000786)	-0.000699	(0.000573)
Married	0.0359	(0.0304)	-0.0184	(0.0219)	0.0362	(0.0305)	-0.0174	(0.0219)
Single	0.00420	(0.0365)	0.00453	(0.0252)	0.00631	(0.0364)	0.00523	(0.0252)
Age Bins	Yes							
N	1,297		1,291		1,297		1,291	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Note: Panel A shows the regression results under the main specifications. Regression results in the first two columns of panel A assume a linear model. Results in the last two columns of panel A assume a probit model. Panel B shows the regression results under OLS with additional control variables. Regression results in the first two columns of panel B include two dummy variables for employees hired before and after the Great Recession. Regression results in the last two columns of panel B include the monthly unemployment rate as an additional control variable. Columns 1 and 3 of both panels estimate the corresponding model using observations made in the first month that employees started to work. Columns 2 and 4 estimate the corresponding model using observations made in the third month that employees started to work. Monthly return is the return rate one would get if he purchased the S&P 500 index at the 1st of the previous month and sold it at the 1st of current month. The variable “Before the Great Recession” takes a value of one for employees hired before December, 2007, the starting date of the Great Recession. The variable “After the Great Recession” takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Unemployment rate is the monthly national unemployment rate adjusted for seasonality. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty is the number of new faculty hired each year. The reference category of marital status consists of all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not report their marital status.

Table 2.9: The effect of stock market returns on TDA participation for faculty

Panel A: main specifications

	OLS				Probit			
	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	-0.562*	(0.295)	-1.245***	(0.220)	-1.432*	(0.770)	-4.474***	(0.897)
Female	-0.00292	(0.0287)	0.0478*	(0.0255)	-0.00789	(0.0731)	0.153*	(0.0791)
Fulltime	-0.125*	(0.0742)	-0.137**	(0.0583)	-0.319*	(0.192)	-0.476**	(0.230)
Income in '000s	0.000733***	(0.000274)	0.000945***	(0.000261)	0.00190***	(0.000719)	0.00315***	(0.00100)
Number of faculty	0.0000356	(0.000365)	-0.000949***	(0.000272)	0.0000735	(0.000923)	-0.00324***	(0.00105)
Married	0.0411	(0.0319)	0.0187	(0.0282)	0.107	(0.0813)	0.0561	(0.0875)
Single	-0.0337	(0.0381)	-0.0176	(0.0348)	-0.0847	(0.0975)	-0.0539	(0.105)
Age Bins	Yes							
N	1,297		1,291		1,297		1,291	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Panel B: OLS with additional control variables

	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	-0.284	(0.364)	0.372	(0.247)	-0.293	(0.316)	-0.467*	(0.243)
Before the Great Recession	-0.0785*	(0.0421)	-0.338***	(0.0257)				
After the Great Recession	0.140	(0.0919)	0.0105	(0.0600)				
Unemployment Rate					5.026**	(2.026)	9.569***	(1.279)
Female	-0.000745	(0.0286)	0.0481*	(0.0248)	-0.00229	(0.0286)	0.0485*	(0.0251)
Fulltime	-0.122*	(0.0737)	-0.109*	(0.0566)	-0.124*	(0.0742)	-0.115**	(0.0573)
Income in '000s	0.000689**	(0.000274)	0.000854***	(0.000256)	0.000702***	(0.000272)	0.000798***	(0.000258)
Number of faculty	0.00136**	(0.000629)	0.00122**	(0.000478)	0.00181**	(0.000814)	0.00237***	(0.000556)
Married	0.0453	(0.0318)	0.0320	(0.0272)	0.0439	(0.0318)	0.0245	(0.0278)
Single	-0.0282	(0.0381)	-0.00599	(0.0339)	-0.0326	(0.0380)	-0.0153	(0.0345)
Age Bins	Yes							
N	1,297		1,291		1,297		1,291	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: Panel A shows the regression results under the main specifications. Regression results in the first two columns of panel A assume a linear model. Results in the last two columns of panel A assume a probit model. Panel B shows the regression results under OLS with additional control variables. Regression results in the first two columns of panel B include two dummy variables for employees hired before and after the Great Recession. Regression results in the last two columns of panel B include the monthly unemployment rate as an additional control variable. Columns 1 and 3 of both panels estimate the corresponding model using observations made in the first month that employees started to work. Columns 2 and 4 estimate the corresponding model using observations made in the third month that employees started to work. Monthly return is the return rate one would get if he purchased the S&P 500 index at the 1st of the previous month and sold it at the 1st of current month. The variable "Before the Great Recession" takes a value of one for employees hired before December, 2007, the starting date of the Great Recession. The variable "After the Great Recession" takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Unemployment rate is the monthly national unemployment rate adjusted for seasonality. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty is the number of new faculty hired each year. The reference category of marital status consists of all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not report their marital status.

Table 2.10: The effect of stock market returns on TDA participation for other employees

Panel A: main specifications

	OLS				Probit			
	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	-0.232	(0.290)	-1.441***	(0.300)	-1.161	(1.296)	-3.805***	(0.811)
Female	0.000993	(0.0155)	-0.00957	(0.0235)	0.00721	(0.0823)	-0.0256	(0.0627)
Fulltime	0.00931	(0.0520)	0.00728	(0.0827)	0.0478	(0.291)	0.0237	(0.216)
Income in '000s	0.00171*	(0.000949)	0.00153	(0.00115)	0.00485*	(0.00283)	0.00360	(0.00295)
Number of faculty	-0.000392**	(0.000154)	-0.00141***	(0.000205)	-0.00190***	(0.000681)	-0.00370***	(0.000545)
Married	-0.0148	(0.0233)	0.0596*	(0.0336)	-0.0555	(0.115)	0.159*	(0.0878)
Single	-0.0584***	(0.0165)	-0.0896***	(0.0302)	-0.372***	(0.125)	-0.246***	(0.0843)
Age Bins	Yes							
N	1,746				1,742		1,745	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: OLS with additional control variables

	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	0.0864	(0.295)	-0.0535	(0.255)	-0.170	(0.287)	-0.522*	(0.268)
Before the Great Recession	-0.0977***	(0.0207)	-0.530***	(0.0249)				
After the Great Recession	-0.0351	(0.0520)	0.0352	(0.0566)				
Unemployment Rate					3.234***	(1.062)	19.53***	(1.213)
Female	0.00299	(0.0154)	0.00478	(0.0205)	0.00203	(0.0155)	-0.000471	(0.0218)
Fulltime	0.0169	(0.0499)	0.0467	(0.0752)	0.0107	(0.0513)	0.0346	(0.0793)
Income in '000s	0.00167*	(0.000961)	0.00112	(0.00110)	0.00162*	(0.000935)	0.000846	(0.00101)
Number of faculty	-0.000221	(0.000233)	0.000435	(0.000277)	0.000397	(0.000288)	0.00342***	(0.000360)
Married	-0.0157	(0.0231)	0.0514*	(0.0297)	-0.0165	(0.0233)	0.0437	(0.0311)
Single	-0.0478***	(0.0164)	-0.0159	(0.0263)	-0.0571***	(0.0165)	-0.0679**	(0.0278)
Age Bins	Yes							
N	1,746							
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Note: Panel A shows the regression results under the main specifications. Regression results in the first two columns of panel A assume a linear model. Results in the last two columns of panel A assume a probit model. Panel B shows the regression results under OLS with additional control variables. Regression results in the first two columns of panel B include two dummy variables for employees hired before and after the Great Recession. Regression results in the last two columns of panel B include the monthly unemployment rate as an additional control variable. Columns 1 and 3 of both panels estimate the corresponding model using observations made in the first month that employees started to work. Columns 2 and 4 estimate the corresponding model using observations made in the third month that employees started to work. Monthly return is the return rate one would get if he purchased the S&P 500 index at the 1st of the previous month and sold it at the 1st of current month. The variable "Before the Great Recession" takes a value of one for employees hired before December, 2007, the starting date of the Great Recession. The variable "After the Great Recession" takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Unemployment rate is the monthly national unemployment rate adjusted for seasonality. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of staff is the number of new staff hired each year. The reference category of marital status consists of all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not report their marital status.

Table 2.11: The effect of stock market returns on TDA contribution for faculty

Panel A: main specifications

	OLS				Tobit			
	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	15.75***	(3.999)	10.79*	(5.628)	9.275	(8.350)	-2.743	(6.879)
Female	-0.339	(0.612)	-0.747	(0.670)	-0.532	(1.152)	-0.260	(0.867)
Fulltime	-1.758	(1.988)	-2.813	(2.327)	-4.502	(3.033)	-4.512*	(2.706)
Income in '000s	0.00431	(0.00499)	0.0158**	(0.00687)	0.0209**	(0.00989)	0.0288***	(0.00896)
Number of faculty	0.0156***	(0.00506)	0.0117*	(0.00641)	0.0211*	(0.0120)	0.00158	(0.00807)
Married	0.343	(0.702)	-0.0365	(0.735)	1.210	(1.293)	0.150	(0.958)
Single	-0.715	(0.709)	0.0383	(0.859)	-1.656	(1.483)	-0.139	(1.143)
Age Bins	Yes							
N / N(Uncensored)	1,297		1,291		1,297/605		1,291/930	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: OLS with additional control variables

	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	9.736**	(4.853)	4.649	(5.798)	13.72***	(4.268)	8.672	(5.660)
Before the Great Recession	1.322*	(0.706)	1.463**	(0.714)				
After the Great Recession	0.509	(1.357)	3.063*	(1.845)				
Unemployment Rate					-37.88	(31.14)	-26.03	(32.64)
Female	-0.330	(0.612)	-0.697	(0.667)	-0.344	(0.611)	-0.749	(0.670)
Fulltime	-1.747	(1.977)	-2.863	(2.311)	-1.765	(1.988)	-2.872	(2.329)
Income in '000s	0.00451	(0.00499)	0.0152**	(0.00688)	0.00455	(0.00504)	0.0162**	(0.00690)
Number of faculty	0.0107	(0.00946)	0.0207*	(0.0106)	0.00227	(0.0114)	0.00266	(0.00983)
Married	0.322	(0.701)	-0.0544	(0.735)	0.321	(0.702)	-0.0524	(0.735)
Single	-0.727	(0.716)	0.0665	(0.861)	-0.723	(0.710)	0.0320	(0.860)
Age Bins	Yes							
N	1,297		1,291		1,297		1,291	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Note: Panel A shows the regression results under the main specifications. Regression results in the first two columns of panel A assume a linear model. Results in the last two columns of panel A assume a tobit model. Panel B shows the regression results under OLS with additional control variables. Regression results in the first two columns of panel B include two dummy variables for employees hired before and after the Great Recession. Regression results in the last two columns of panel B include the monthly unemployment rate as an additional control variable. Columns 1 and 3 of both panels estimate the corresponding model using observations made in the first month that employees started to work. Columns 2 and 4 estimate the corresponding model using observations made in the third month that employees started to work. Monthly return is the return rate one would get if he purchased the S&P 500 index at the 1st of the previous month and sold it at the 1st of current month. The variable "Before the Great Recession" takes a value of one for employees hired before December, 2007, the starting date of the Great Recession. The variable "After the Great Recession" takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Unemployment rate is the monthly national unemployment rate adjusted for seasonality. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty is the number of new faculty hired each year. The reference category of marital status consists of all other marital statuses, including divorced, living

Table 2.12: The effect of stock market returns on TDA contribution for other employees

Panel A: main specifications

	OLS				Tobit			
	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	-2.767	(2.693)	3.697	(2.611)	-17.25	(15.98)	-10.21**	(4.700)
Female	0.0383	(0.163)	0.168	(0.241)	0.197	(1.078)	0.133	(0.509)
Fulltime	-0.649	(0.722)	-0.816	(0.876)	-1.274	(4.080)	-0.966	(1.795)
Income in '000s	0.00866*	(0.00470)	0.0233*	(0.0139)	0.0584*	(0.0302)	0.0410*	(0.0240)
Number of faculty	0.000593	(0.000929)	0.00192	(0.00190)	-0.0166**	(0.00825)	-0.0119***	(0.00339)
Married	-0.149	(0.154)	0.575	(0.429)	-0.911	(1.413)	1.357*	(0.769)
Single	0.104	(0.293)	0.0657	(0.352)	-3.106*	(1.614)	-1.042	(0.737)
Age Bins	Yes							
N / N(Uncensored)	1,746				1,746/207		1,746/736	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: OLS with additional control variables

	First month data		Third month data		First month data		Third month data	
	1		2		3		4	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	-1.548	(2.750)	5.835**	(2.643)	-2.601	(2.664)	5.301**	(2.643)
Before the Great Recession	-0.376*	(0.196)	-0.957***	(0.291)				
After the Great Recession	-0.536*	(0.311)	-0.440	(0.583)				
Unemployment Rate					8.640	(7.754)	34.05**	(13.70)
Female	0.0453	(0.165)	0.194	(0.241)	0.0410	(0.164)	0.184	(0.241)
Fulltime	-0.606	(0.719)	-0.729	(0.880)	-0.646	(0.721)	-0.769	(0.881)
Income in '000s	0.00858*	(0.00488)	0.0227	(0.0141)	0.00841*	(0.00466)	0.0221	(0.0137)
Number of faculty	-0.000315	(0.00173)	0.00324	(0.00315)	0.00270	(0.00226)	0.0104***	(0.00398)
Married	-0.152	(0.154)	0.561	(0.431)	-0.154	(0.155)	0.548	(0.431)
Single	0.134	(0.283)	0.183	(0.348)	0.108	(0.292)	0.103	(0.351)
Age Bins	Yes							
N	1,746							
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Note: Panel A shows the regression results under the main specifications. Regression results in the first two columns of panel A assume a linear model. Results in the last two columns of panel A assume a tobit model. Panel B shows the regression results under OLS with additional control variables. Regression results in the first two columns of panel B include two dummy variables for employees hired before and after the Great Recession. Regression results in the last two columns of panel B include the monthly unemployment rate as an additional control variable. Columns 1 and 3 of both panels estimate the corresponding model using observations made in the first month that employees started to work. Columns 2 and 4 estimate the corresponding model using observations made in the third month that employees started to work. Monthly return is the return rate one would get if he purchased the S&P 500 index at the 1st of the previous month and sold it at the 1st of current month. The variable "Before the Great Recession" takes a value of one for employees hired before December, 2007, the starting date of the Great Recession. The variable "After the Great Recession" takes a value of one for employees hired after June 2009, the ending data of the Great Recession. Unemployment rate is the monthly national unemployment rate adjusted for seasonality. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of staff is the number of new staff hired each year. The reference category of marital status consists of all other marital statuses, including divorced,

Table 2.13: Summary of the effect of the stock market returns

Panel A: Probability of choosing the DC plan as the mandatory retirement savings plan

	Faculty	
	First month data	Third month data
OLS	0.990***	0.444*
OLS with Great Recession fixed effects	0.677*	0.0270
OLS with unemployment rate	0.760**	0.213
Probit	2.672***	1.961**

Panel B: Voluntary TDA participation rate

	Faculty		Staff	
	First month data	Third month data	First month data	Third month data
OLS	-0.562*	-1.245***	-0.232	-1.441***
OLS with Great Recession fixed effects	-0.284	0.372	0.0864	-0.0535
OLS with unemployment rate	-0.293	-0.467*	-0.170	-0.522*
Probit	-1.432*	-4.474***	-1.161	-3.805***

Panel C: Voluntary TDA contribution rate

	Faculty		Staff	
	First month data	Third month data	First month data	Third month data
OLS	15.75***	10.79*	-2.767	3.697
OLS with Great Recession fixed effects	9.736**	4.649	-1.548	5.835**
OLS with unemployment rate	13.72***	8.672	-2.601	5.301**
Tobit	9.275	-2.743	-17.25	-10.21**

Note: This table summarizes key regression results when the monthly S&P 500 return is the key right hand side variable. Panel A summarizes results for mandatory DC plan participation, Panel B summarizes results on the TDA plan participation, and Panel C summarizes results on the TDA plan contribution.

Table 2.14: Robustness check: the effect of stock market returns on mandatory DC participation

	Linear probability model				Probit model			
	1		2		3		4	
	First month data		Third month data		First month data		Third month data	
Mandatory DC Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	0.899***	(0.335)	0.152	(0.291)	2.449***	(0.895)	0.639	(1.125)
Female	-0.0625	(0.0401)	-0.0253	(0.0310)	-0.166	(0.108)	-0.0985	(0.124)
Fulltime	-0.221***	(0.0820)	0.0371	(0.0875)	-0.664**	(0.282)	0.119	(0.295)
Income in '000s	0.000590*	(0.000319)	0.000347	(0.000303)	0.00187*	(0.00106)	0.00138	(0.00124)
Number of faculty	-0.0000943	(0.000436)	-0.0000333	(0.000357)	-0.000260	(0.00121)	0.00000879	(0.00148)
Married	0.0242	(0.0435)	-0.0192	(0.0348)	0.0608	(0.118)	-0.0771	(0.133)
Single	-0.00627	(0.0544)	0.0568	(0.0381)	-0.0181	(0.146)	0.262	(0.184)
Age Bins	Yes							
N	625		623		625		623	

Note: Equation 2.5 is estimated using employees hired between 2007 and 2010 only. Regression results in the first two columns are estimated using a linear model. Column 1 uses observations made in the first month that employees started to work, while Column 2 uses observations made in the third month that employees started to work. Regression results in the last two columns are estimated using a probit model. Column 3 uses observations made in the first month that employees started to work, and Column 4 uses observations made in the third month that employees started to work. Monthly return is the return rate one would get if he purchased the S&P 500 index on the 1st of previous month and sold it on the 1st of current month. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty is the number of faculty hired each year. The reference category of marital status is all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not to report their marital status.

Table 2.15: Robustness check: the effect of stock market returns on TDA participation

Panel A: faculty

	Linear probability model				Probit model			
	1		2		3		4	
	First month data		Third month data		First month data		Third month data	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	-0.382	(0.330)	-1.111***	(0.259)	-0.994	(0.865)	-4.845***	(1.257)
Female	-0.0343	(0.0414)	0.0466	(0.0316)	-0.0860	(0.105)	0.195	(0.127)
Fulltime	-0.211**	(0.0964)	-0.128**	(0.0572)	-0.557**	(0.279)	-0.617*	(0.364)
Income in '000s	0.000838**	(0.000370)	0.000439	(0.000310)	0.00222**	(0.00103)	0.00176	(0.00131)
Number of faculty	0.0000491	(0.000460)	-0.00120***	(0.000363)	0.0000915	(0.00116)	-0.00485***	(0.00156)
Married	-0.00149	(0.0453)	0.0497	(0.0350)	-0.00211	(0.115)	0.191	(0.136)
Single	-0.0110	(0.0570)	0.0265	(0.0433)	-0.0249	(0.144)	0.0927	(0.171)
Age Bins	Yes							
N	625		623		625		623	

Panel B: other employees

	Linear probability model				Probit model			
	1		2		3		4	
	First month data		Third month data		First month data		Third month data	
TDA Participation	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	-0.187	(0.332)	-1.445***	(0.294)	-0.839	(1.249)	-4.063***	(0.902)
Female	0.0258	(0.0246)	0.00101	(0.0320)	0.108	(0.103)	0.00138	(0.0871)
Fulltime	0.0231	(0.0784)	0.123	(0.117)	0.101	(0.360)	0.346	(0.297)
Income in '000s	0.00133	(0.00105)	0.000319	(0.000800)	0.00364	(0.00281)	0.000783	(0.00203)
Number of staff	-0.000445**	(0.000195)	-0.00160***	(0.000237)	-0.00183**	(0.000735)	-0.00442***	(0.000698)
Married	-0.0429	(0.0337)	0.0841**	(0.0422)	-0.173	(0.143)	0.236*	(0.122)
Single	-0.0902***	(0.0298)	-0.0305	(0.0487)	-0.460**	(0.183)	-0.0820	(0.131)
Age Bins	Yes							
N	926				914		926	

Note: Equation 2.5 is estimated using employees hired between 2007 and 2010 only. Regression results in the first two columns are estimated using a linear model. Column 1 uses observations made in the first month that employees started to work, while Column 2 uses observations made in the third month that employees started to work. Regression results in the last two columns are estimated using a probit model. Column 3 uses observations made in the first month that employees started to work, and Column 4 uses observations made in the third month that employees started to work. Panel A estimates the model using observations among faculty, whereas panel B estimates the model using data for other employees. Monthly return is the return rate one would get if he purchased the S&P 500 index on the 1st of previous month and sold it on the 1st of current month. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty (staff) is the number of faculty (staff) hired each year. The reference category of marital status is all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not to report their marital status.

Table 2.16: Robustness check: the effect of stock market returns on TDA contribution

Panel A: faculty

	Linear model				Tobit model			
	1		2		3		4	
	First month data		Third month data		First month data		Third month data	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	15.30***	(4.420)	8.211	(6.868)	13.30*	(7.870)	-1.879	(7.911)
Female	-0.511	(0.773)	-0.612	(0.900)	-1.207	(1.318)	-0.234	(1.044)
Fulltime	-0.279	(1.668)	-3.005	(3.580)	-3.413	(2.444)	-4.249	(3.712)
Income in ’000s	-0.00111	(0.00406)	0.00183	(0.00683)	0.0133	(0.00934)	0.00743	(0.00896)
Number of faculty	0.0171**	(0.00703)	0.00729	(0.0104)	0.0227*	(0.0132)	-0.00366	(0.0122)
Married	-0.973	(0.893)	-0.481	(0.954)	-1.324	(1.476)	-0.0985	(1.128)
Single	-1.258	(0.992)	-0.611	(1.230)	-1.802	(1.742)	-0.394	(1.440)
Age Bins	Yes							
N	625		623		625		623	
N (Uncensored)	625		623		325		509	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: other employees

	Linear model				Tobit model			
	1		2		3		4	
	First month data		Third month data		First month data		Third month data	
TDA Contribution	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	-2.435	(2.830)	4.055	(2.920)	-10.22	(11.45)	-5.332	(3.915)
Female	0.425**	(0.203)	0.311	(0.366)	1.633	(0.999)	0.390	(0.549)
Fulltime	-0.263	(0.697)	0.220	(0.841)	-0.114	(3.556)	1.035	(1.709)
Income in ’000s	0.00572	(0.00434)	0.0173	(0.0127)	0.0329	(0.0234)	0.0218	(0.0174)
Number of staff	0.0000578	(0.00121)	0.00187	(0.00269)	-0.0109*	(0.00632)	-0.00873**	(0.00352)
Married	-0.372*	(0.201)	0.734	(0.692)	-1.936	(1.289)	1.385	(0.937)
Single	-0.406**	(0.196)	-0.375	(0.305)	-4.049**	(1.761)	-0.725	(0.636)
Age Bins	Yes							
N	926							
N (Uncensored)	926				154		548	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Note: Equation 2.5 is estimated using employees hired between 2007 and 2010 only. Regression results in the first two columns are estimated using a linear model. Column 1 uses observations made in the first month that employees started to work, while Column 2 uses observations made in the third month that employees started to work. Regression results in the last two columns are estimated using a tobit model. Column 3 uses observations made in the first month that employees started to work, and Column 4 uses observations made in the third month that employees started to work. Panel A estimates the model using observations among faculty, whereas panel B estimates the model using data for other employees. Monthly return is the return rate one would get if he purchased the S&P 500 index on the 1st of previous month and sold it on the 1st of current month. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty (staff) is the number of faculty (staff) hired each year. The reference category of marital status is all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not to report their marital status.

Table 2.17: Robustness check: Existing employees

Panel A: faculty

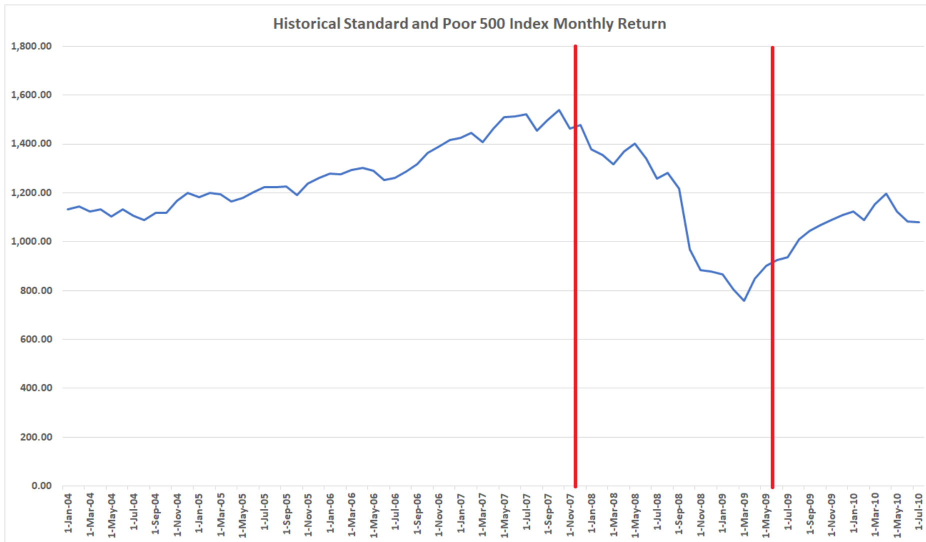
	TDA Participation				TDA Contributions			
	1		2		3		4	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	0.336***	(0.112)	0.161	(0.1000)	6.321**	(3.207)	2.668**	(1.048)
Female	0.0368**	(0.0150)			0.852*	(0.436)		
Fulltime	-0.0670**	(0.0304)	0.00673	(0.0170)	-5.294***	(1.301)	-2.573***	(0.764)
Income in '000s	0.00107***	(0.000124)	0.000567***	(0.000141)	-0.00181	(0.00265)	-0.0205***	(0.00460)
Number of faculty	-0.0000338***	(0.00000243)	-0.0000116***	(0.00000142)	-0.000406***	(0.0000590)	-0.000349***	(0.0000339)
Married	-0.00377	(0.0362)	-0.00774	(0.0274)	-0.511	(1.108)	1.081**	(0.498)
Single	-0.0133	(0.0365)	-0.0812**	(0.0328)	-0.0394	(1.116)	0.893	(0.645)
Individual fixed effect			Yes				Yes	
Age Bins	Yes							
N	359,324							
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Panel B: other employees

	TDA Participation				TDA Contributions			
	1		2		3		4	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Monthly return	-0.0827	(0.282)	-0.00599	(0.0475)	-0.0242	(4.410)	-0.199	(0.439)
Female	0.0522***	(0.0161)			0.504**	(0.198)		
Fulltime	-0.151***	(0.0398)	0.0110	(0.0201)	-4.321***	(0.892)	-2.003***	(0.749)
Income in '000s	0.00665***	(0.00152)	0.000955**	(0.000444)	0.0635***	(0.0170)	0.0283**	(0.0129)
Number of faculty	-0.0000167***	(0.00000193)	-0.00000745***	(0.000000896)	0.0000520**	(0.0000237)	-0.0000168	(0.0000125)
Married	0.0721***	(0.0272)	0.0501	(0.0307)	0.760**	(0.305)	0.224	(0.376)
Single	-0.0368	(0.0250)	-0.000190	(0.0319)	0.0309	(0.269)	-0.274	(0.378)
Individual fixed effect			Yes				Yes	
Age Bins	Yes							
N	485,061							
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$								

Note: Equation 2.5 is estimated using employees hired before January 2004. The first two columns show the regression results for TDA participation decisions, while the last two columns show the results for TDA contribution decisions. Compared to columns 1 and 3, columns 2 and 4 add individual fixed effects to the regression and remove the female indicator because the gender effect is part of the individual fixed effects. Panel A estimates the model using observations among faculty, whereas panel B estimates the model using data for other employees. Monthly return is the return rate one would get if he purchased the S&P 500 index on the 1st of previous month and sold it on the 1st of current month. Full-time is an indicator that takes a value of one for full-time employees. Female takes a value of one if the gender of the employee is female. Income is the imputed annual income for the employee measured in thousands of 2018 dollars. Number of faculty (staff) is the number of faculty (staff) hired each year. The reference category of marital status is all other marital statuses, including divorced, living together, widowed, and unknown. The marital status is unknown for employees who do not to report their marital status.

Figure 2.1: S&P 500 Index from January 2004 to June 2010

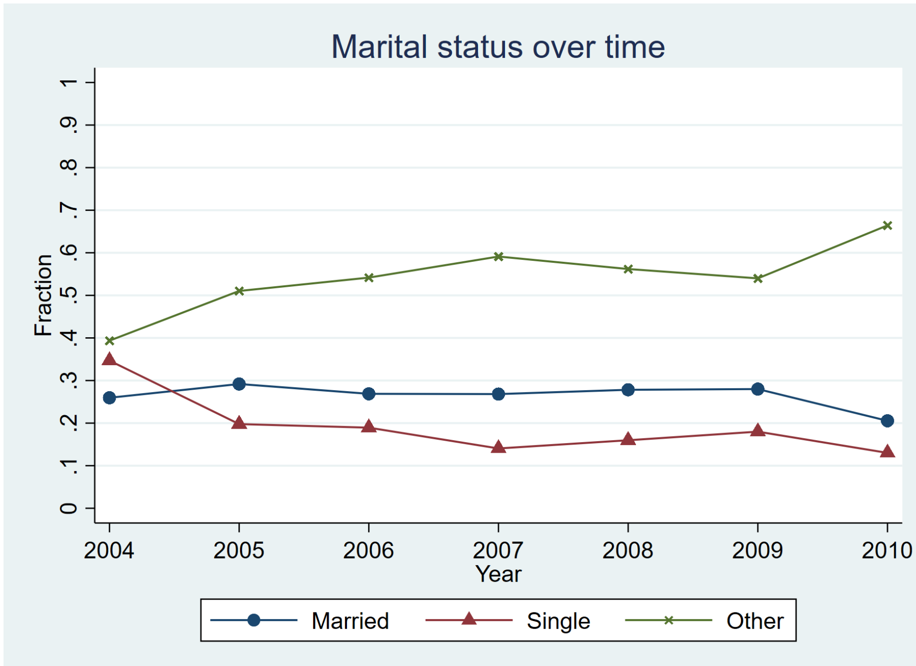


Note: The graph shows the value of the S&P 500 index from January 2004 to July 2010. The two red vertical lines indicate the starting and ending months of the Great Recession.

Figure 2.2: Distribution of imputed annual income vs. distribution of actual annual income

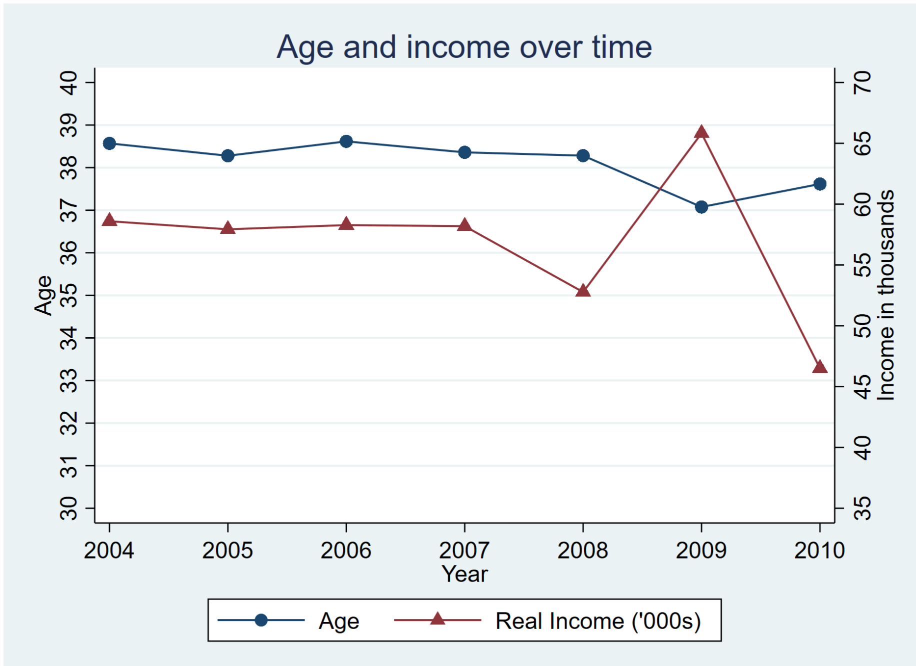
Figure 2.3: Fraction of gender, full time workers, and faculty by year

Figure 2.4: Fraction of different marital statuses by year



Note: All of the averages are calculated using the first month data for employees hired between January 2004 and June 2010. The line connected by filled circles represents the fraction of new employees who in a given year are married. The line connected by triangles represents the fraction of new employees who in a given year are single. Lastly, the line connected by Xs represents the fraction of new employees who in a given year are neither married nor single.

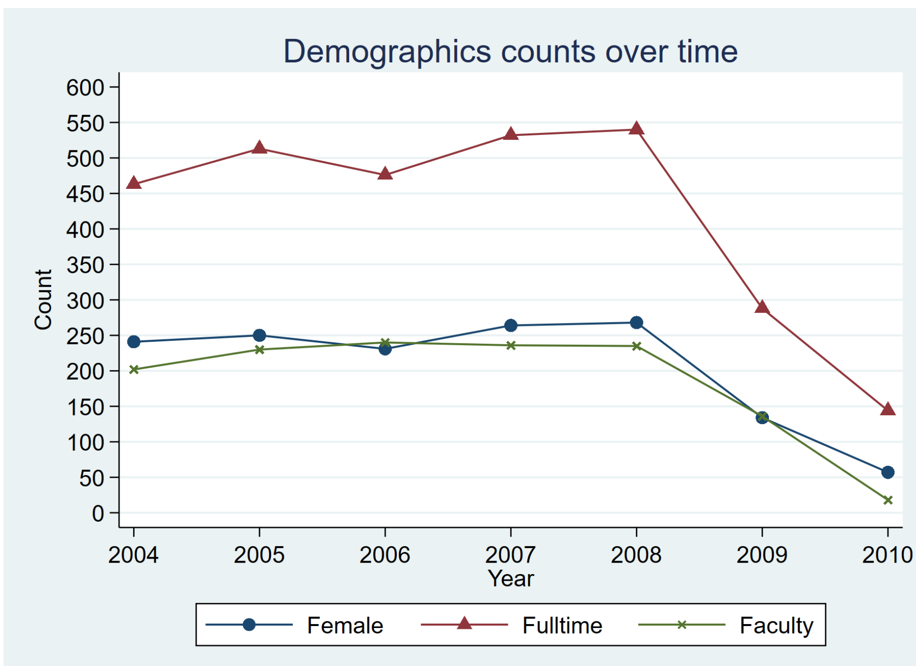
Figure 2.5: Age and annual income by year



Note: All of the averages are calculated using the first month data for employees hired between January 2004 and June 2010. The line connected by filled circles represents the average age of new employees each year. The line connected by triangles represents the average annual income measured in thousands of 2018 dollars among new employees each year.

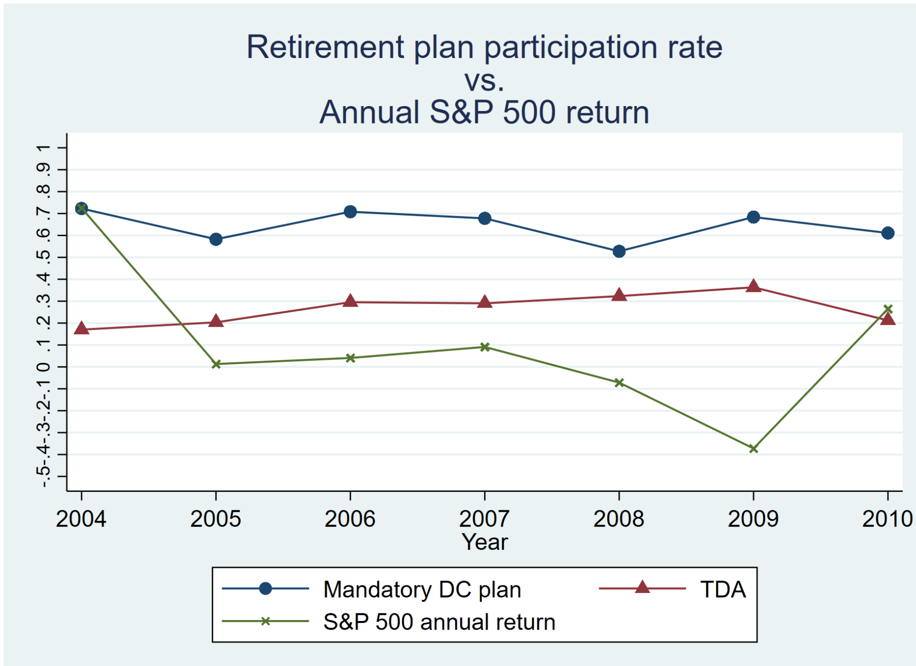
Figure 2.6: Distribution of real income in 2008 and real income in 2009

Figure 2.7: Number of gender, full time workers, and faculty by year



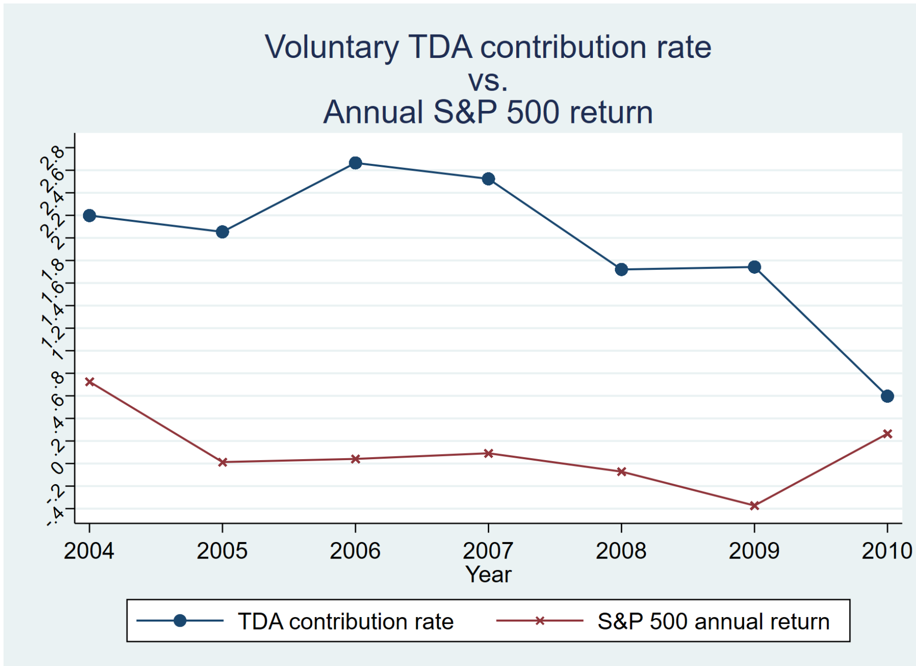
Note: The line connected by filled circles represents the number of female employees hired each year. The line connected by triangles represents the number of full time employees hired each year. Lastly, the line connected by Xs represents the number of faculty hired each year.

Figure 2.8: Correlation between the plan participation rate and stock market returns



Note: All of the averages are calculated using the first month data for employees hired between January 2004 and June 2010. The line connected by filled circles represents the fraction of new employees who chose the DC plan each year. The line connected by triangles represents the fraction of new employees who own at least one TDA each year. The line connected by cross marks represents the annual return rate of the S&P 500 index.

Figure 2.9: Correlation between the voluntary TDA contribution rate and stock market returns



Note: All of the averages are calculated using the first month data for employees hired between January 2004 and June 2010. The line connected by filled circles represents the average contribution rate of new employees each year. The line connected by cross marks represents the annual return rate of the S&P 500 index.

Chapter 3

Beyond Discrete Choice: Estimating Consumer Preferences Using Continuous Choices of Health Insurance Coverage

(coauthored with Leora Friedberg and Adam Leive)

3.1 Introduction

A growing number of studies use micro-data on insurance choices to empirically estimate risk aversion and other parameters of consumer preferences (O'Donoghue & Somerville (2018), Barseghyan *et al.* (2018)). Research has examined consumer choices across a range of insurance products, including health insurance, property insurance, and auto insurance. In each context, detailed data on individual-level claims is used to construct a distribution of loss probabilities, which may differ based on individual characteristics, and is taken as the consumer's beliefs about spending. These beliefs are then combined with consumer choices from a menu of different coverage levels and a specified utility model to estimate consumer preferences, evaluate welfare, and conduct counterfactual analyses.

One empirical challenge is that variation in choice sets is often limited. Prior literature has studied settings in which consumers choose from a discrete number of coverage levels (e.g. three insurance deductibles), rather than make a continuous choice of how much coverage to purchase. Such restricted choice sets characterize most real-world offerings, but observed choices from such menus only identify sets of risk aversion or other preference parameters that are consistent with the given choice. To obtain point-identification, the econometrician must make distributional assumptions on the parameters. Whether such assumptions are correct is an open question, as is what the implications are for characterizing preferences, making counterfactual predictions, and measuring welfare if these assumptions are wrong.

In this paper, we exploit the continuous choice of health insurance coverage via Flexible Spending Accounts (FSAs) to estimate consumer preferences. An FSA provides supplemental coverage as the insurance policy, and consumers make dollar-level pre-tax contributions concurrently with their deductible choice. We use administrative data from a large employer in the education sector that offered employees a choice of two different deductibles for health insurance along with the option to make FSA contributions. The panel data includes information on medical and pharmacy spending, health insurance choices, employee salary, firm tenure, and demographics. We first specify two canonical expected utility models in which consumers have preferences satisfying constant absolute risk aversion (CARA) or constant relative risk aversion (CRRA), and numerically solve for risk aversion person-by-person in each year.

We find that standard models that assume risk aversion are unlikely to explain observed insurance choices. Most consumers are found to be risk neutral, contributing less to their FSA than their expected out-of-pocket costs. The estimated distribution of risk aversion does not follow either a normal or log-normal distribution, which are common assumptions made in the literature. We also find that the estimated risk aversion coefficients vary substantially from one year to the next for the same person, which is inconsistent with the standard assumption of time-invariant risk preferences. In our setting, about one-quarter of employees make positive FSA contributions. Taking revealed preferences seriously, the most parsimonious version of the neoclassical model with diminishing marginal utility of consumption is unlikely to be correct for explaining insurance decisions when stakes are modest. Instead, loss aversion is likely to better explain choices, a point first made by Rabin (2000) and Rabin & Thaler (2001).

Our results contribute to a growing number of studies that measure risk preferences using real-world insurance decisions (Cohen & Einav (2007), Einav *et al.* (2012), Handel (2013), Handel & Kolstad (2015)). To the best of our knowledge, this is the first paper that uses a continuous measure of coverage choice to relax distributional assumptions in modeling risk aversion. Our findings add to several studies that demonstrate that standard expected utility models with diminishing marginal utility of wealth are poorly suited to explain choices over small financial stakes, and that incorporating behavioral factors or information frictions is important (Rabin (2000), Sydnor (2010), Barseghyan *et al.* (2013), Handel & Kolstad (2015)).

The rest of this paper is organized as follows. Section 3.2 describes the model and identification of risk preferences. Section 3.3 describes the institutional details of FSA and health insurance plans offered in the setting. Section 3.4 describes our calibration and Section 3.5 presents results. Section 3.6 briefly concludes and discusses limitations.

3.2 Model

This section first outlines a standard model of insurance choices when consumers make selections from a discrete menu of plans. As neoclassical benchmarks, we consider two utility functions: (1) CARA, so that for consumption x, $u(x) = -\frac{1}{\gamma}e^{-\gamma x}$, where γ is the coefficient of absolute risk aversion, and (2) CRRA, so that $u(x) = \frac{x^{1-\rho}-1}{1-\rho}$, where ρ is the coefficient of relative risk aversion. We first discuss what data variation identifies risk aversion under these two formulations when consumers make a discrete choice of plans. We then integrate FSAs into this standard model to allow for consumers to make continuous choices of insurance coverage.

3.2.1 Standard model of insurance plan choice

Employees choose a health insurance contract that pays a portion of health care costs in return for an insurance premium. Higher premiums provide more generous coverage, defined as lower out-of-pocket payments. In the neoclassical model of insurance choice, employees choose the plan that maximizes expected utility given their risk aversion, claim probability, and marginal tax rate. For employee k, a consumption draw under insurance plan j is specified as:

$$x_{kj} = (y_k - \pi_j)(1 - \tau_k) - OOP_{kj} \tag{3.1}$$

where y_k denotes income, π_j denotes the plan premium, τ_k is the employee's marginal tax rate (inclusive of federal, state, and FICA taxes), and OOP_{kj} is an out-of-pocket realization under plan j based on employee k's ex ante cost distribution F_k. The equation reflects the tax preference for health insurance that allow premiums to be paid with pre-tax dollars, while out-of-pocket payments are paid with after-tax dollars. Employees have a discrete choice of J insurance plans and choose the plan that maximizes their expected utility, defined as:

$$U_{kj}\left(\gamma_k, F_k\left(OOP_{kj}\right)\right) = \int_0^\infty u\left(x_{kj}\right) dF_k\left(OOP_{kj}\right) \tag{3.2}$$

For a given cost distribution F and marginal tax rate τ, the choice of plan identifies a set of risk aversion for each employee consistent with expected utility maximization, because there is a finite menu of insurance contracts to choose from. With two plans, for example, there will be a threshold level of risk aversion above which a person would choose more generous coverage in return for a higher premium. Variation in prices (premiums and marginal tax rates), coverage (deductibles, coinsurance, out-of-pocket limits), or loss probabilities can narrow down the set of risk aversion coefficients. Repeated choices by consumers to changes in plan menus over time can be used for this purpose, assuming that risk preferences are stable within-person. In practice, such empirical variation is limited so that additional assumptions must be made to obtain point identification on risk aversion. Researchers generally model risk aversion as a random coefficient and allow it to vary among the population, specifying that the parameter follows either a normal or lognormal distribution. With data on demographics, the mean and variance of the random coefficient may vary with observable characteristics of the consumer. Parameter estimation is often based on simulated maximum likelihood that matches observed to predicted choices (Train (2009)).

3.2.2 Model with FSAs

An FSA is a tax-preferred financial account to fund cost sharing related to health insurance (e.g. deductibles and copays), dental and vision expenses, and some other health expenses not covered by insurance. Contributions are exempt from federal income tax, state income tax, and FICA taxes. The decision of how much to contribute is made concurrently with the plan choice and cannot be adjusted throughout the year. There is an annual limit to contributions.[1] FSAs are characterized by a "use it or lose it" feature: unused funds are forfeited at the end of the year.[2]

FSAs thus represent supplemental insurance coverage, with each additional dollar of coverage costing consumers $1-\tau$ cents. With FSAs, the consumption draw becomes:

$$x_{kj}(w|\pi,\tau) = (y_k - \pi_j - w_{kj})\,(1-\tau_k) - OOP_{kj} + \underbrace{\min\{OOP_{kj}, w_{kj}\}}_{\text{FSA withdrawal}} \tag{3.3}$$

where w represents FSA contributions. FSAs therefore allow consumers to make a continuous choice of the amount of insurance coverage. The simultaneous choice of both insurance plan and FSA contributions can be interpreted as an example of

[1]The annual limit was \$5,000 until 2013, when it was reduced to \$2,500. In 2019, the maximum is \$2,900.

[2]Before 2005, all FSA funds were forfeited to the employer at the end of each calendar year. In 2005, the Internal Revenue Service (IRS) added a short grace period that permitted employees to use the funds by March 15th of next year. Beginning in 2013, the Health Care Cost Reduction Act allowed up to \$500 of unused FSA funds to roll over to the next year. Employers can choose to either allow for the 2.5 month grace period or the \$500 roll-over, but not both options.

the discrete/continuous model of Dubin & McFadden (1984), which studies appliance choices and electricity consumption. Without any hassle costs or other frictions, a consumer would choose to make FSA contributions up until the point at which the value of the last dollar in terms of risk reduction is equal to the price of that contribution, $1 - \tau$. The choice of FSA contributions thus pins down the consumer's risk preferences, given their marginal tax rate and beliefs about loss probabilities. We next describe our setting and data, which provide necessary inputs to equation (3), before discussing implementation.

3.3 Setting and Data

We use administrative data on payroll records and insurance claims from a large employer in the education sector. We focus on choices in 2012 and 2013 because the employer introduced a high-deductible health plan with a Health Savings Account in 2014. During our study period, employees could choose from two plans: (1) a high coverage plan with a \$200 deductible, 10% co-insurance rate, and a \$5,000 maximum out of pocket limit, and (2) a low coverage plan with a \$700 deductible, 20% co-insurance rate, and a \$7,000 maximum out of pocket limit. Co-pays and other cost sharing were also higher for the low coverage plan. The deductibles and out-of-pocket limits were half of the above amounts for employees purchasing coverage for themselves only. These amounts refer to care for in-network providers. Deductibles, co-insurance, and out-of-pocket limits for out-of-network providers were higher for both plans. The cost sharing of these plans did not change during these two years. The employer offered an FSA to employees in both years.

We construct a novel panel data set consisting of annual FSA contributions, health insurance choices, earnings, and demographics, including age, gender, and tenure with the employer. Annual earnings of employees are collapsed into bins of $5,000 to maintain data confidentiality. We impute annual earnings using publicly available data on the distribution of annual employee salary from the employer. We draw randomly from the appropriate band in the publicly available data to create a measure of annual salary for each employee in our sample. We assume a uniform distribution of earnings for salary bins that are not included in the public record. Figure 1.2, which compares the distribution of imputed annual earnings (the solid curve) to earnings distribution from the public record (the dashed curve), shows that the distribution of imputed earnings is close to the distribution of earnings in the publicly available data.

For each employee and dependent, we observe aggregated information on medical and pharmacy spending, but do not have detailed insurance claims. Instead, we observe the annual amounts spent by the plan, annual amounts spent by the policyholder (separated by deductibles and copays), and spending for in-network and out-of-network providers. We use this information to construct distributions of expected total health spending and expected out-of-pocket spending for each person, described in the next section.

We make three sample restrictions to focus on the choice of insurance coverage for expenses that are uncertain. First, we exclude individuals with at least $500 out-of-network health care expenditure in either 2011, 2012, or 2013, since some of this coverage may be anticipated. This results in dropping approximately 15 percent of the sample. Second, we exclude individuals with different number of dependents across 2012 and 2013 since these changes in family composition may also be anticipated (e.g. births). Finally, we restrict attention to the large majority of employees (77 percent) who choose the high coverage plan because our data currently lacks the granularity required to accurately model out-of-pocket expenditures in the low coverage plan. After these restrictions, our analytic sample includes data on 23,148 person-years split over a two-year period. The first four columns of Table 2.1 show summary statistics among our sample. The average FSA participation rate is 24% over the two years. Including zeros, employees contribute $361 per year, on average, to their FSAs. Mean expected out-of-pocket health care spending is $1,484 under the high premium plan. We calculate marginal tax rates using imputed income and NBER's TAXSIM program. Employees face a federal income marginal tax rate of 17 percent, on average. Including state and FICA taxes (assuming the incidence is fully on the employee) increases the marginal tax rate to 34 percent. Our calibrations use the total marginal tax rate to calculate risk aversion. In terms of health insurance, half of employees have employee-only coverage. The employee's portion of the monthly premium is $133, averaged across coverage levels.

Columns 5 to 8 of Table 2.1 present results for the sub-sample who make positive FSA contributions and are enrolled in the high coverage plan. This group contains 3,910 person-years representing 2,373 unique employees. Among this sub-sample, the average FSA contribution is $1,473 and the average expected out-of-pocket payment is $1,874. Those contributing to the FSA are less likely to have employee-only coverage, but otherwise earn similar salaries.

3.4 Calibration Methods

This section describes how we implement the model of FSA contributions outlined in Section 2 to calibrate risk aversion. In addition to imputing income and marginal tax rates as described in the previous section, the distribution of out-of-pocket expenditure is a required input to calculate expected utility. We construct distributions of out-of-pocket expenses using the previous year's spending for each employee combined with an assumption of rational expectations and the plan's cost sharing rules. More specifically, we fit a statistical model to the empirical distribution of spending for people with different combinations of age, gender, and quintile of lagged health spending. This assumes employees have "rational expectations" insofar as their spending follows the same distribution as others with the same demographics and prior health spending. We then aggregate these distributions within households to create a household measure of beliefs regarding next year's spending given their demographics and past history. To predict out-of-pocket spending under the employer's insurance plan, we apply the cost sharing rules to this distribution to arrive at a distribution of out-of-pocket spending. We take this statistical object as the employee's subjective beliefs about their loss probabilities. Appendix A provides the technical details of this procedure.

With the inputs for expected utility in hand, the next step is to calculate the optimal FSA contribution over a fine grid of risk aversion coefficients. We consider coefficients of absolute risk aversion ranging from 0 (risk-neutral) to 0.05 in increments of 10^{-6}, and coefficients of relative risk aversion from 0 (risk-neutral) to 10 in increments of 0.01. For each candidate risk aversion level, we numerically solve for the FSA contribution that maximizes expected utility, using an algorithm based on a combination of golden search and parabolic interpolation. Finally, we select the risk aversion level that minimizes the difference between predicted FSA contributions and observed FSA contributions. This process is repeated for each person in each year of the data.

3.5 Results

3.5.1 Descriptive Evidence

Before showing the calibration results, we present descriptive patterns of FSA contributions and expected out-of-pocket spending that preview the main findings. Table 3.2 shows quantiles of these variables among people with positive FSA contribution. The third row of Table 3.2 shows the summary statistics of FSA contribution less expected out-of-pocket expenditure. The majority of people contribute less than their expected out-of-pocket spending, with an average difference of $400 (roughly 20 percent of expected costs). Figure 3.2 shows the density of this difference, with much of the distribution concentrated around zero. To examine how this relationship varies with the level of out-of-pocket spending, Figure 3.3 displays a binned scatterplot of FSA contributions against expected out-of-pocket spending. If people were risk neutral, their FSA contribution would equal their expected out-of-pocket spending, as depicted by the 45 degree line. FSA contributions in excess of expected out-of-pocket expenditure is consistent with risk aversion: people would be willing to pay more than their expected loss as an insurance premium. This pattern is generally observed for levels of out-of-pocket spending below $1,000, represented by points above the 45 degree line. By contrast, most FSA contributions are less than expected out-of-pocket spending at moderate to high levels of expected spending. These patterns are difficult to reconcile with risk aversion and expected utility as a model for consumer preferences in this context, as a large fraction of potential losses are not insured.

3.5.2 Calibration Results

Turning now to the more formal analysis, Panel A of Table 3.3 shows the summary statistics for the estimated CARA coefficients in each year. For ease of interpretation, Panel B of the same table translates these coefficients into the maximum amount x an individual would be willing to lose in a lottery offering a 50-50 chance of winning \$100 or losing x. Mathematically, the numbers in panel B of Table 3.3 are calculated to solve $\{x : u(w) = \frac{1}{2}u(w+100)+\frac{1}{2}u(w-x)\}$ with $u(w) = \frac{1}{\gamma}e^{-\gamma w}$. For CARA utility, x is independent of the value of w.

Over half of the sample is risk neutral, with risk aversion coefficients of zero. The mean risk aversion level, however, is quite high at over 0.006, which translates into a willingness to lose roughly \$60 in terms of the above 50-50 lottery. The average is dragged up by the high upper bound used in the calibration, though, so that this statistic is arguably less meaningful than the different quantiles. The calibration generates such high levels of risk aversion for employees making FSA contributions that far exceed their expected spending (e.g. by two thousand dollars or more). If such spending estimates are correct (a point which we return to in the conclusion), then only implausibly high values of risk aversion can rationalize this choice.

Figure 3.4 shows the distribution of risk aversion levels by year, still for CARA utility. To make the graphs more readable, we exclude observations with risk aversion at the upper and lower bounds. Figure 3.5, 3.6, and **??** further stratify the distributions by year-gender, year-age, and the combination of year, gender and age. The distribution of CARA coefficients does not appear to be either normal or log-normal in any of the graphs.

Finally, Figure 3.8 shows a binned scatter plot of risk aversion in 2012 versus 2013 for the same individual, among those who made positive FSA contributions in both years. There is clearly a positive relationship (the correlation coefficient equals 0.39). Yet if the other components of the model are correct, the risk aversion coefficients should be identical. The median difference is zero, indicating the same estimate in both years. But for many people, estimated risk aversion varies substantially from one year to the next. The standard deviation of this difference is 0.01, which is large in magnitude for CARA coefficients.

The patterns are qualitatively similar in considering CRRA utility, as shown in Table 3.4. These calculations use each person's imputed annual salary as their wealth level. We obtain qualitatively similar results using salary per household member instead. Most people are again found to be risk neutral, although we do not obtain any of the extremely levels of risk aversion as we did for CARA utility. Figure 3.9, Figure 3.10, 3.11, and 3.12 show the distribution of CRRA risk aversion coefficients by year, year-gender, year-age, and the combination of year, gender, and age, respectively. Again, the graphs indicate that the risk aversion does not follow either a normal or log-normal distribution. As a formal test, we perform Shapiro-Francia normality tests for both CARA and CRRA risk aversion coefficients. (See Shapiro & Francia (1972) for the details of the test.) The test results reject the null hypothesis that CARA (CRRA) risk aversion coefficients follow a normal or log-normal distribution at the 1% level.

3.6 Conclusion

We use administrative data on health insurance and FSA choices among employees at a large firm to estimate risk aversion levels. FSAs enable consumers to purchase supplemental coverage in one-dollar increments on top of their existing plan. We leverage this continuous choice of insurance coverage to point-identify risk aversion while making fewer assumptions than required in settings where consumers choose from a discrete menu of plans. We find that most consumers are risk neutral, and make lower FSA contributions than their expected out-of-pocket spending. The distribution of risk aversion coefficients does not follow either a normal or log-normal distribution, which are common assumptions made in the literature. We also find that our calculations of risk aversion vary substantially over a two-year period for the same individual. Taken together, this evidence suggests that CARA or CRRA utility combined with expected utility is likely the wrong model to explain choices involving risky outcomes at modest stakes.

The most plausible explanation for observed choices is loss aversion. The likelihood that loss aversion explains financial decisions over small stakes has been suggested by Rabin (2000) and Rabin & Thaler (2001). In our context, unused FSA contributions may feel like losses if they are forfeited. In comparison, the gains from tax deductability are experienced less favorably by consumers. FSA contributions that fall short of out-of-pocket costs require after-tax financing—which reduces consumption more because of the tax preferences of FSAs—but no FSA funds are "lost" in case of a shortfall. In canonical models featuring loss aversion (Kahneman & Tversky (1979)), a loss hurts twice as much as a gain of the same size, evaluated with respect to the reference point. What the reference point is in this context is unclear a priori, but one might argue that gains are losses are evaluated with respect to either the default of no FSA contribution, or the expected level of out-of-pocket payments.

The study has a number of limitations. First, our calibration still makes a number of assumptions. Marginal tax rates are imputed based on individual salary, which are also imputed. We do not observe spousal earnings or assets beyond company retirement accounts. Home equity and IRAs, for example, are important assets that we lack information on, and would affect both wealth and tax-filing behavior. Our marginal tax rates may thus be measured with error. We also necessarily specify consumer beliefs regarding their future out-of-pocket spending. Doing so admittedly entails a number of important and untestable assumptions. We model consumers as having rational expectations, being able to predict the full distribution of health care spending based on their demographic information, past spending, and experiences of similar coworkers. We further assume that consumers apply the plan's cost sharing rules to map this distribution of total health spending onto a distribution of out-of-pocket spending. Although this approach to specify beliefs is standard in the literature, it is unlikely that consumers in fact possess such detailed information about their spending risk. Other research points to the presence of mistakes in understanding specific features of insurance plans (Handel & Kolstad (2015), Brot-Goldberg *et al.* (2017)). An important topic for future research is to measure beliefs in detail using surveys, and to compare these measures to standard assumptions of rationale expectations. Such information could further help develop models of decision-making that reflect how people make choices over risky financial outcomes.

Appendix A: Construction of Out-of-Pocket Cost Distributions

This section describes in detail the procedure for constructing distributions of out-of-pocket costs for each insured family (employee only or the employee and dependents). It follows similar methods as Handel (2013) and Handel & Kolstad (2015). This cost model assumes that there is no moral hazard and that each person in the same risk group holds the same beliefs about his or her ex ante health expenditure risk. There are four steps to construct the distributions from the inputs of expenditure claims and the employer's past medical and pharmacy spending.

1. Group each insured individual i into risk group z based on age, sex, and health status

2. For each risk group, construct a Weibull distribution, G_z, that is modified to allow for the possibility of zero expenditure using observed total health expenditure m from the following year

3. For each person in risk group z, simulate expenditure draws from G_z and add up the draws within each family k to create an ex ante distribution of total health expenditure risk G_k for family k

4. For each family k, map the distribution of expenditure risk G_k to out-of-pocket costs under deductible j to create a family-specific ex ante distribution of out-of-pocket costs F_{jk} of choosing deductible j

Risk groups: Each individual i is first categorized into risk group z based on their age, sex, and quintile of the previous year's health spending. The age bins used are ¡30, 30-34, 35-39, 40-44, ..., 60-64, 65 and older. We pool all years together to ensure adequate sample sizes. This process results in 90 risk groups based on six age bins, gender, and quintiles of previous health spending. The size of each risk group exceeds 1,000 people.

Expenditure distributions by risk group: After the risk groups are defined, the observed expenditures for each person in the group the following year are used to estimate an ex ante expenditure distribution for that group. Denote the empirical distribution of claims the following year by $\widehat{G}_{I_z}$. In constructing this distribution, expenditures on preventive care are excluded since such services are covered free of charge by all plans. Only claims from in-network providers are considered, which comprise over 98 percent of all spending. We continuously fit this empirical distribution using a Weibull distribution with a mass of claims at zero to generate an ex ante distribution of expenditure risk.

The creation of this ex ante distribution of expenditure by risk group involves two steps to deal with the mass of expenditure at zero. First, for each risk group k, the empirical probability of zero expenditure is used to construct the mass of expenditure realizations at zero, denoted $\widehat{G}_{I_z}(0)$. Second, a Weibull distribution is fitted to the observed expenditures that are positive in that risk group by maximizing the following likelihood with respect to the scale parameter α and shape parameter β:

$$\prod_{i \in I_z} \frac{\beta_z}{\alpha_z} \left(\frac{m_i}{\alpha_z} \right)^{\beta_z - 1} e^{-\left(\frac{m_i}{\alpha_z}\right)^{\beta_z}}$$

Denote $\widehat{\alpha_z}$ and $\widehat{\beta}_z$ as the estimated parameters and $W\left(\widehat{\alpha_z}, \widehat{\beta}_z\right)$ as the distribution of positive expenditure in risk group z. The (ex ante) distribution for expenditure in risk group z is then:

$$G_z = \begin{cases} \widehat{G}_{I_z}(0) & \text{if } m = 0 \\ \widehat{G}_{I_z}(0) + \frac{W\left(\widehat{\alpha_z}, \widehat{\beta_z}\right)}{1-\widehat{G}_{I_z}(0)} & \text{if } m > 0 \end{cases}$$

Simulated expenditures: For each insured individual within each risk group, 100 draws are simulated from the corresponding expenditure distribution G_z. Then within each family k, the expenditures for each draw from each member are summed, so that each family has 100 draws corresponding to the family's total expenditure. This statistical object, denoted G_k, represents the beliefs of family k about its total health expenditure risk. Since families differ in their compositions by age, sex, severity score, and size, this classification by risk group results in over 22,150 different combinations of expected spending in the sample.

Expenses not covered by health insurance: The procedure described above uses data on medical and pharmacy spending, which are covered by health insurance. Spending on dental and vision services are included in separate plans, if elected by the employee, and not observed in our data. In addition, FSAs can be used to finance a range of other health-related items, like sunscreen, first aid, some over-the-counter medication, among others. To be conservative, we assume that spending on these items is $250 per household member, a number that is roughly equal to the amount on dental services (Yarbrough *et al.* (2016)). We assume that these expenses are incurred with certainty, given that they represent items that usually involve pre-payment rather than insurance.

Table 3.1: Summary Statistics

	Overall				Estimation Sample			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
FSA Participation	24.00%	42.71%	0	1	100.00%	0.00%	1	1
FSA Contribution	361.54	832.74	0	5000	1473.17	1033.12	10	5000
Expected OOP under High Premium Plan	1484.90	1104.79	306.57	6705.58	1874.01	1217.52	306.57	5901.99
Federal Marginal Tax Rate	17%	0.06	0.1	0.396	17%	0.06	0.1	0.396
Total Marginal Tax Rate	34%	0.09	0.129	0.4915	33%	0.10	0.129	0.4915
Household Size	2.13	1.35	1	11	2.24	1.38	1	10
Health Insurance Plan								
High Premium	77.17%	41.98%	0	1	100.00%	0.00%	1	1
Low Premium	22.83%	41.98%	0	1	0.00%	0.00%	0	0
Health Insurance Coverage Tier								
Employee Only	46.35%	49.87%	0	1	39.82%	48.96%	0	1
Employee Plus Child/Children	17.15%	37.70%	0	1	18.03%	38.45%	0	1
Employee Plus Spouse	15.73%	36.41%	0	1	19.82%	39.87%	0	1
Family	20.77%	40.57%	0	1	22.33%	41.65%	0	1
Health Insurance Premium	133.38	119.19	12	394	177.88	128.37	49	394
N (Person-Year)	23,148				3,910			

Note: Overall sample contains observations made in 2012 and 2013 with complete FSA contribution, earnings, and health insurance plan information. Also, we exclude observations with arrears payment in any retirement savings plan in any year because individuals with arrears payment can be subject to different budget constraints. We further exclude observations with high out of network cost and different number of dependents in across the two years. The sample being estimated contains observations with positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

Table 3.2: Summary Statistics on FSA Contribution and Expected OOP Expenses

Variable	Mean	Std Dev	5%	25%	Median	75%	95%
Annual FSA Contribution	1473.17	1033.12	270	660	1200	2000	3500
Expected OOP	1874.01	1217.52	424.42	824.46	1653.67	2778.16	4167.25
Difference	-400.84	1264.42	-2629.42	-1179.96	-290.61	330.22	1580.23
N				3,910			

Note: Data among people with positive FSA contribution and purchased high premium health insurance in both 2012 and 2013. Difference is defined as annual FSA contribution minus expected OOP spending.

Table 3.3: CARA risk aversion coefficients

Panel A: Raw Estimation

Year	Obs	Mean	Std Dev	Min	25%	Median	75%	Max
2012	1,986	0.0063	0.0102	0	0	0	0.0109	0.0499
2013	1,924	0.0068	0.0104	0	0	0	0.0131	0.0499
Overall	3,910	0.0065	0.0103	0	0	0	0.0118	0.0499

Panel B: Translation

Year	Obs	Mean	Std Dev	Min	25%	Median	75%	Max
2012	1986	61.07	48.57	100	100	100	46.73	13.82
2013	1924	58.84	48.02	100	100	100	41.90	13.82
Overall	3910	59.95	48.29	100	100	100	44.50	13.82

Note: Panel A shows the CARA risk aversion coefficients estimated using observations with positive FSA contribution and low deductible health insurance. Panel B translate the risk aversion coefficients into the amount of lose that makes an individual with corresponding CARA risk aversion would be indifferent between a 50-50 bet of winning \$100 and losing that amount vs not taking the bet at all. Mathematically speaking, panel B translate the risk aversion coefficients into {x:u(w) = 0.5*u(w+100)+0.5*u(w-x)}. Since we are using CARA utility function, the value of x does not depend on wealth level w.

Table 3.4: CRRA risk aversion coefficients

Panel A: Raw Estimation

Year	Obs	Mean	Std Dev	Min	25%	Median	75%	Max
2012	1,986	0.16	0.24	0	0	0	0.52	1
2013	1,924	0.16	0.24	0	0	0	0.5	0.85
Overall	3,910	0.16	0.24	0	0	0	0.5	1

Panel B: Translation

Year	Obs	Mean	Std Dev	Min	25%	Median	75%	Max
2012	1986	99.98	99.97	100	100	100	99.94	99.88
2013	1924	99.98	99.97	100	100	100	99.94	99.90
Overall	3910	99.98	99.97	100	100	100	99.94	99.88

Note: Panel A shows the CRRA risk aversion coefficients estimated using observations with positive FSA contribution and low deductible health insurance. Panel B translate the risk aversion coefficients into the amount of lose that makes an individual with corresponding CRRA risk aversion would be indifferent between a 50-50 bet of winning $100 and losing that amount vs not taking the bet at all. Mathematically speaking, panel B translate the risk aversion coefficients into {x:u(w) = 0.5*u(w+100)+0.5*u(w-x)}. During the translation, the wealth level, w, is assumed to be $81,000.

Figure 3.1: Imputed annual income vs. annual income from public data

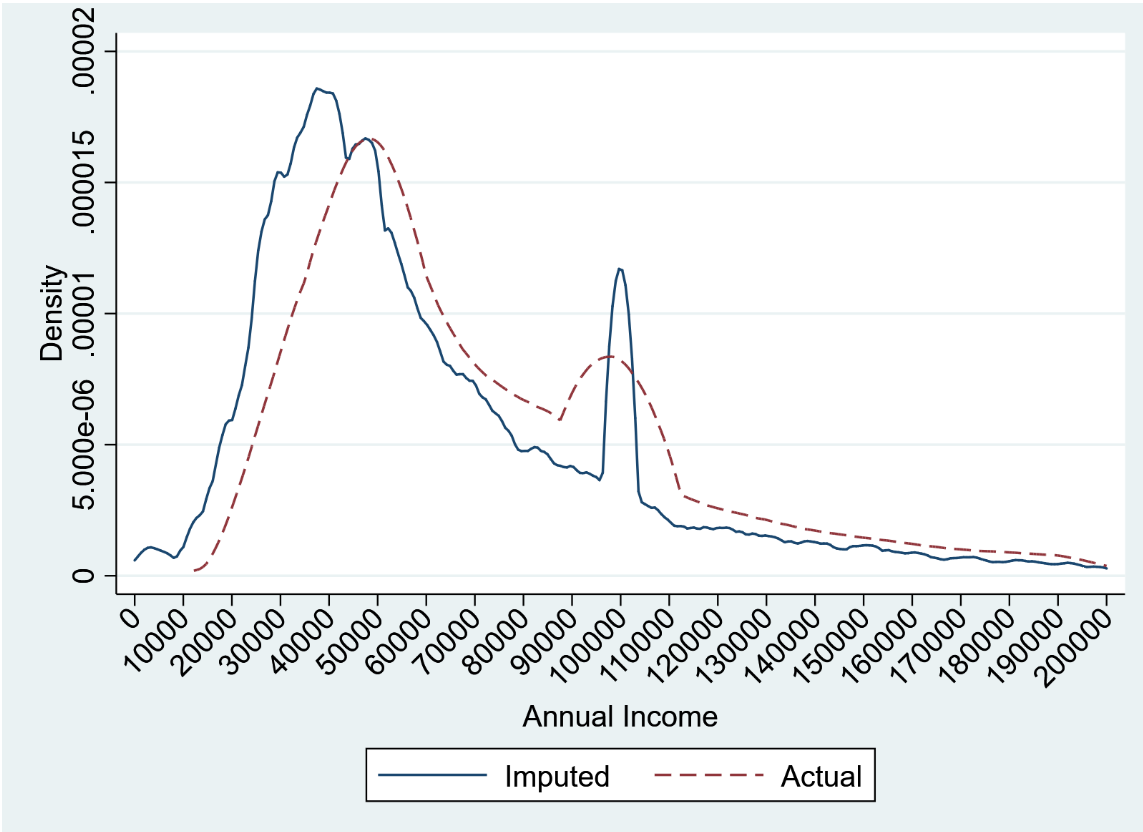
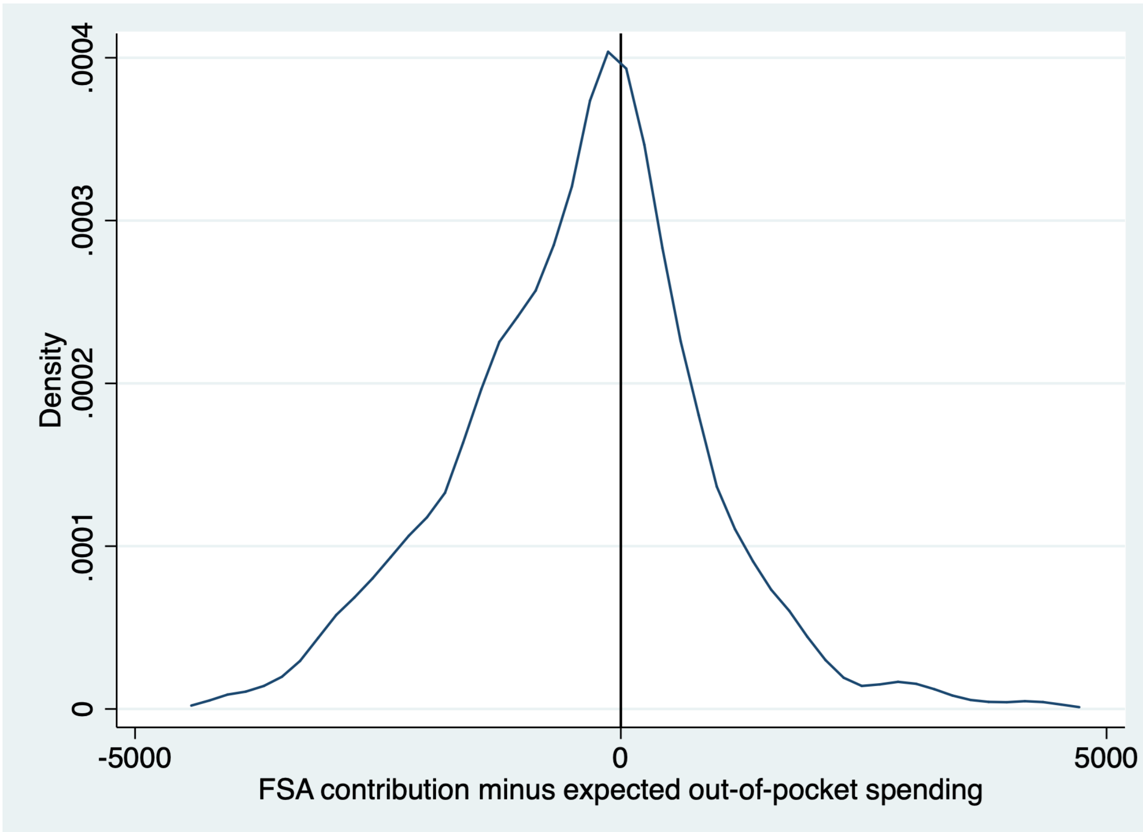
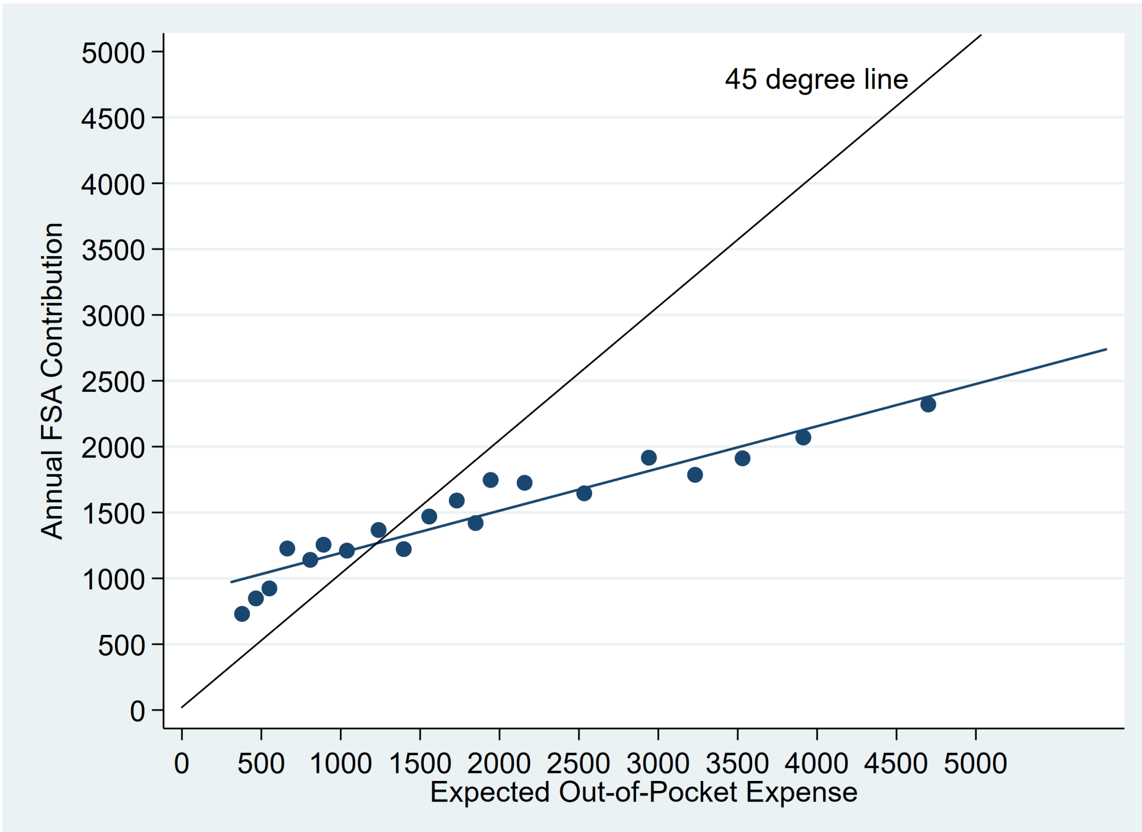


Figure 3.2: Density of FSA contribution relative to expected OOP spending



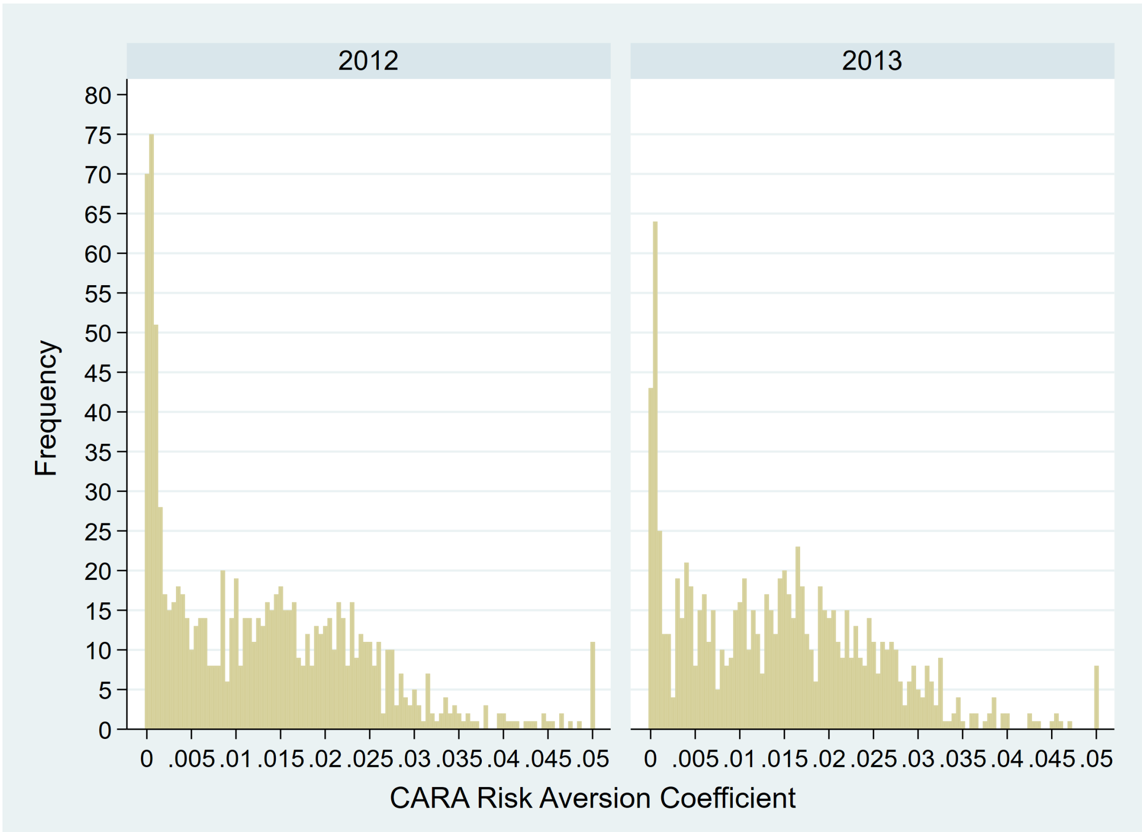
Note: This graph plots the kernel density of FSA contributions less expected out-of-pocket spending across both 2012 and 2013. Epanechnikov kernel and a bandwidth of 192.5 are used. The vertical line at 0 denote observations that contribute an amount to their FSA equal to expected spending.

Figure 3.3: Binned scatter plot of FSA contribution vs expected OOP expense



Note: Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

Figure 3.4: Distribution of CARA risk aversion levels by year, excluding boundaries

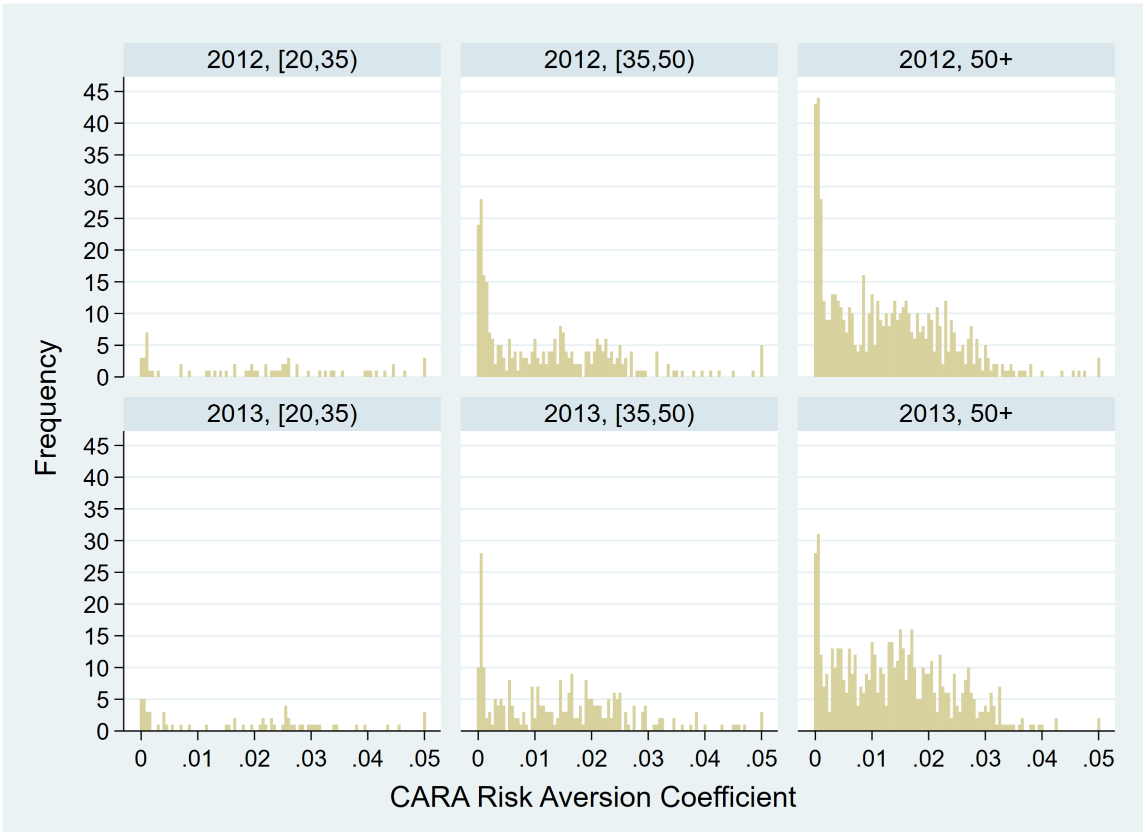


Note: Bin width is 0.0005. Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

Figure 3.5: Distribution of CARA risk aversion levels by year and gender, excluding boundaries

Note: Bin width is 0.0005. Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

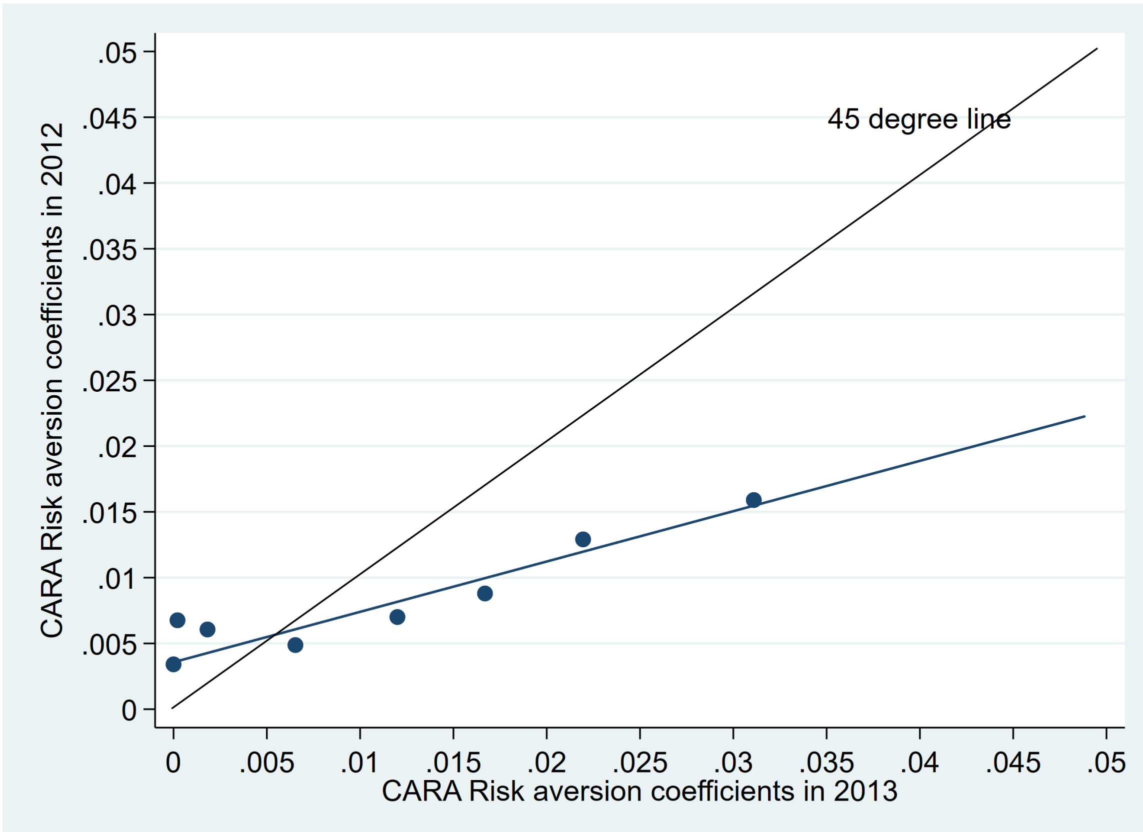
Figure 3.6: Distribution of CARA risk aversion levels by year and age, excluding boundaries



Note: Bin width is 0.0005. Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

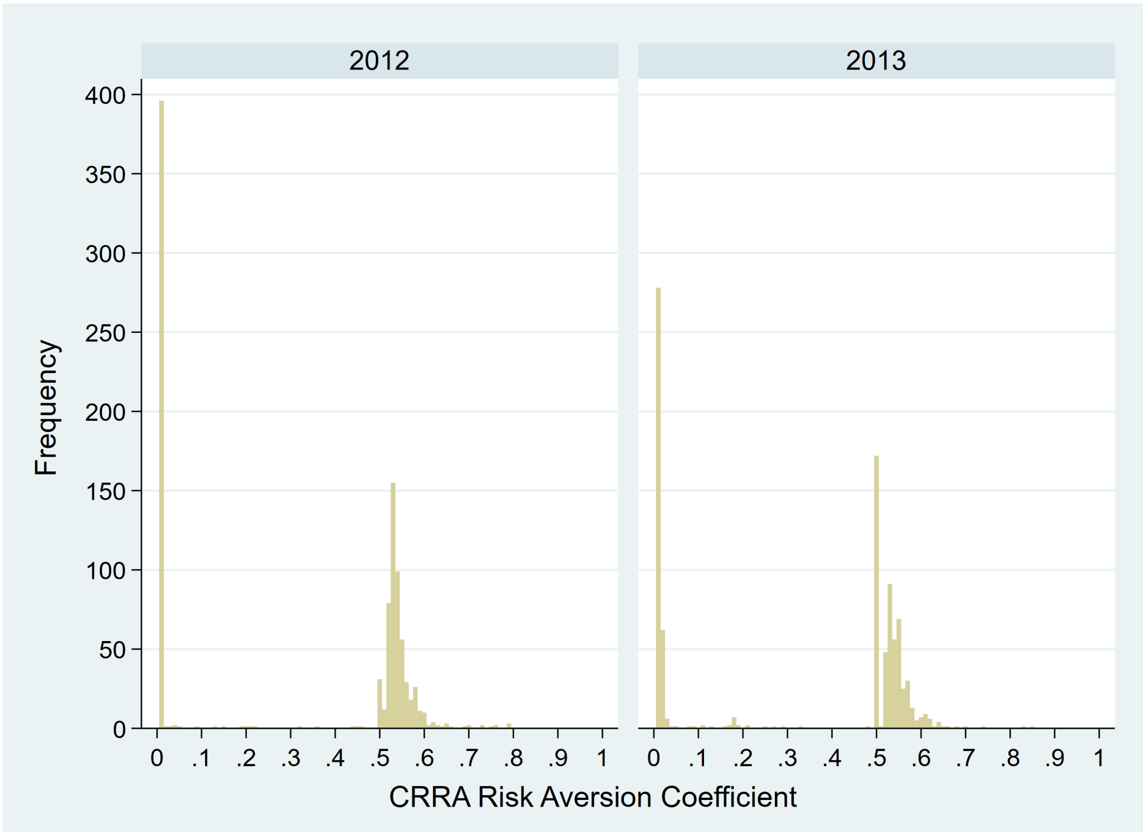
Figure 3.7: Distribution of CARA risk aversion levels by year, age, and gender, excluding boundaries

Figure 3.8: CARA risk aversion within individual across time, binned scatter plot



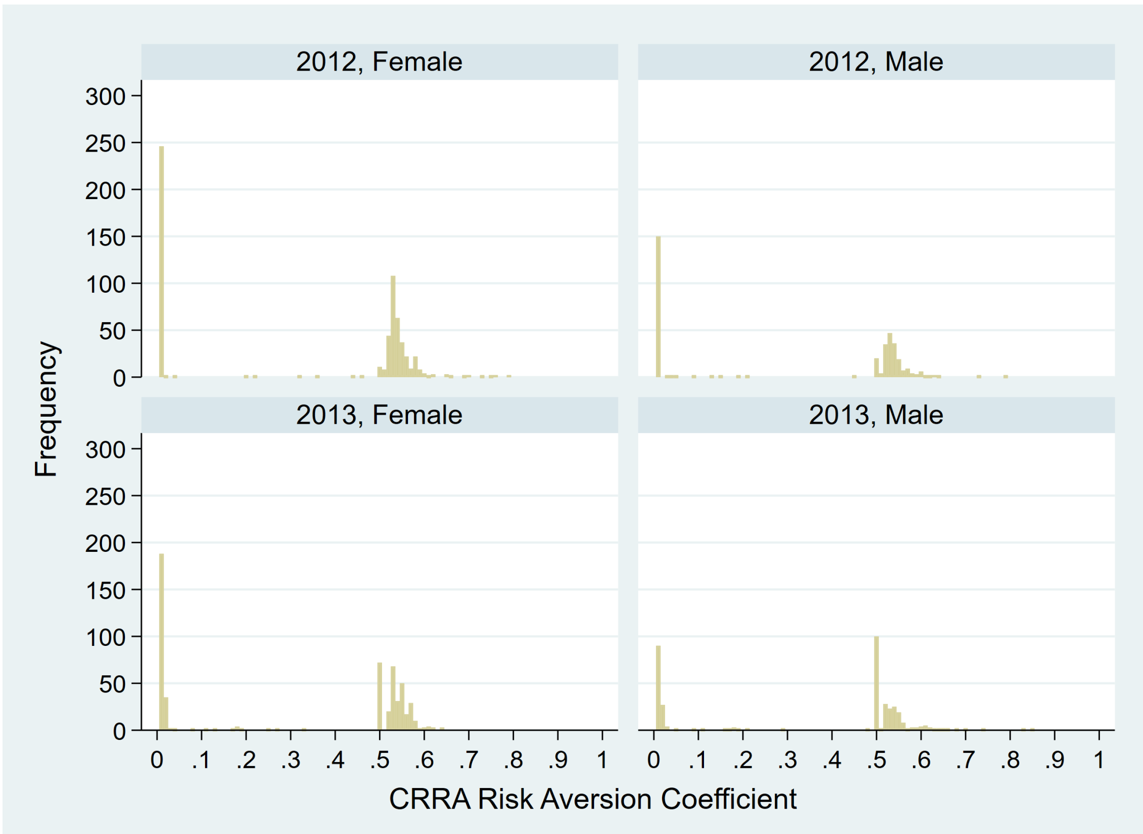
Note: Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

Figure 3.9: Distribution of CRRA risk aversion levels by year, excluding boundaries



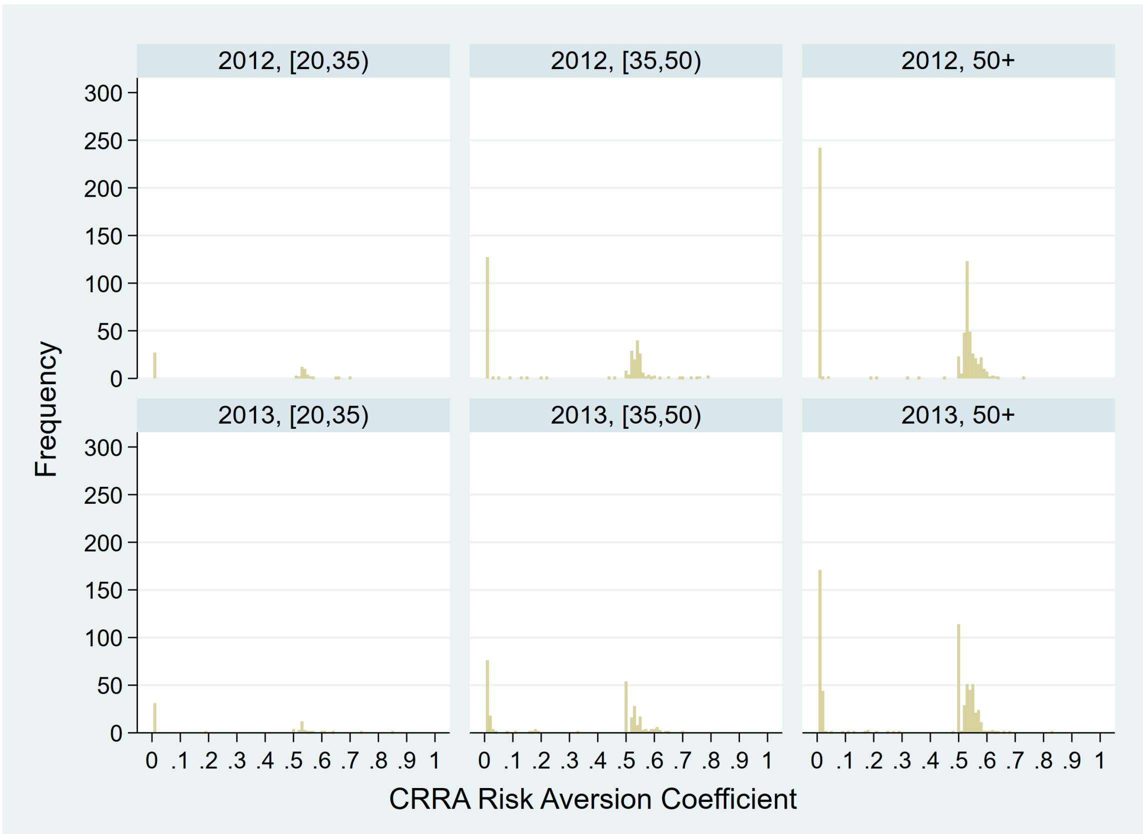
Note: Bin width is 0.01. Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

Figure 3.10: Distribution of CRRA risk aversion levels by year and gender, excluding boundaries



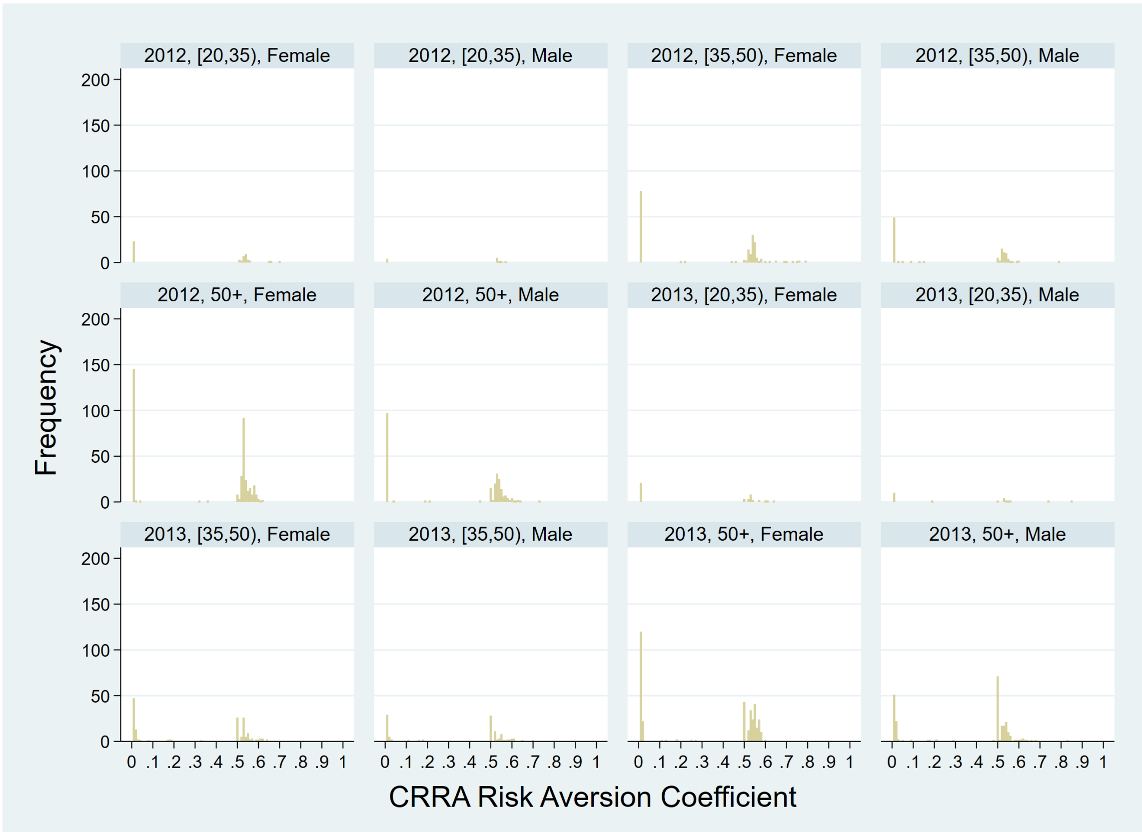
Note: Bin width is 0.01. Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

Figure 3.11: Distribution of CRRA risk aversion levels by year and age, excluding boundaries



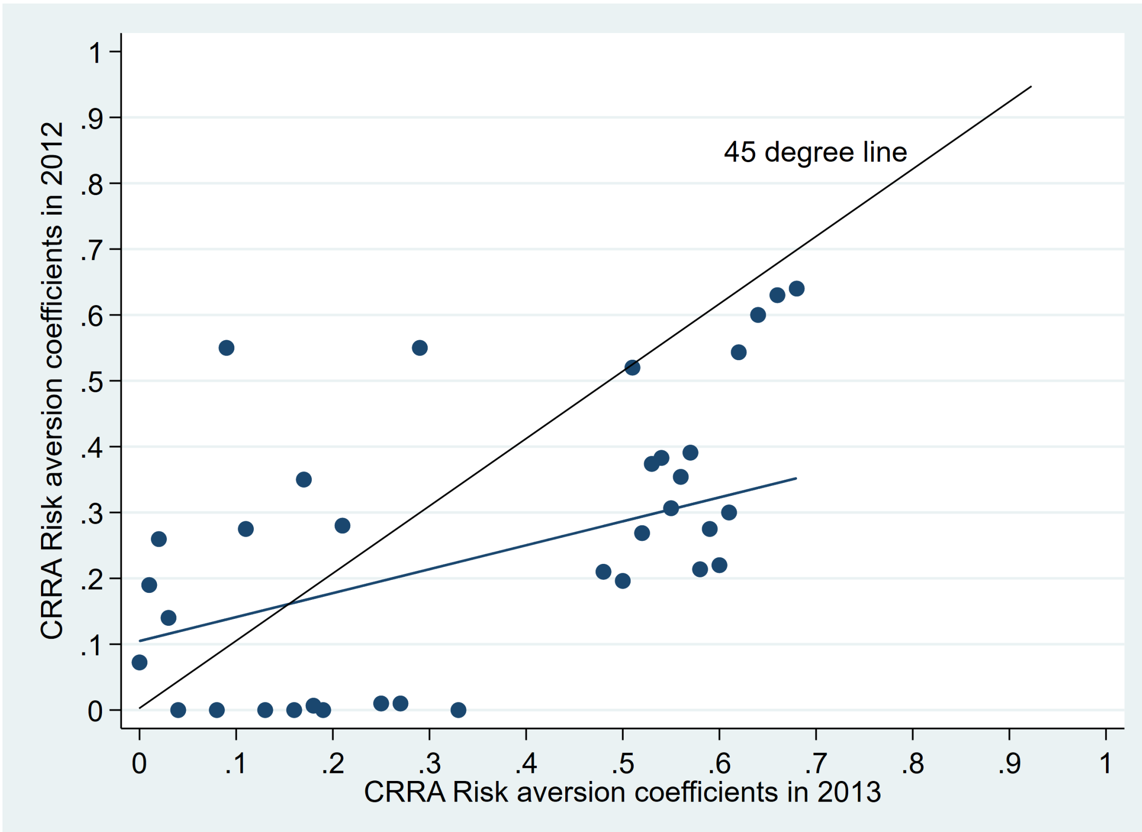
Note: Bin width is 0.01. Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

Figure 3.12: Distribution of CRRA risk aversion levels by year, age, and gender, excluding boundaries



Note: Bin width is 0.01. Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

Figure 3.13: CRRA risk aversion within individual across time, binned scatter plot



Note: Using data among people who made positive FSA contributions in both 2012 and 2013 and purchased the high premium health insurance plan.

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