Household Savings and Portfolio Choice

by

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Abstract

This thesis consists of three essays that examine household savings and portfolio choice behavior. Chapter One analyses the effects of employer matching contributions and tax incentives on participation and contribution behavior in employer-sponsored 401(k) savings plans. Employer sponsored retirement savings plans consist of several different incentives designed to increase employee savings, including matching contributions, tax deductibility, and tax free compounding. There is a substantial literature on the effects of match rates on retirement savings, but little on the effects of preferential tax treatment. This chapter provides estimates of the impact of employer matching and tax deductibility on retirement savings using a uniquely suited dataset from a large United States Corporation. I estimate that the effect of a one percentage point change in the match rate corresponds to a 0.06 percentage point increase in savings plan participation rates, while a similar one percentage point increase in marginal tax rates increases participation by 1.35 percentage points. Changes in the match rate have an insignificant effect on contribution rates (conditional on participation), though a one percentage point change in marginal tax rates tends to increase contribution rates by 0.16 percentage points. The effects of the match rate and marginal tax rate are transformed into changes in the annualized rate of return of the savings plan and this disparity remains. Finally, these estimates are used to calculate the changes in wealth at retirement due to changes in match rates and marginal tax rates under a variety of parameterizations.

Chapter Two examines the trading and contribution behavior of employees participating in the 401(k) plan at a large United States corporation. This corporation offers employer matching contributions in company stock, and employees are prohibited from trading the matching contributions for an extended period. The empirical work details evidence of rebalancing behavior that is impacted by vesting restrictions and within-firm variation in match rates. Employees are between 3 and 7 percentage points more likely to rebalance their retirement portfolio once matching contributions have fully vested, and an additional 6 to 11 percentage points more likely if they face a 100% match rate relative to a 50% match rate. Variation in match rates also

leads to changes in composition of employee contributions: increases in the match rate lead to decreases in the amount of company stock that the employee purchases with their own funds. Employees are between 13 and 19 percentage points less likely to contribute their own income to the matched asset and, if they still contribute to company stock, the employee's own-money contributions in company stock fall by between 13 and 18 percentage points. Together, these estimates provide evidence that employee contribution and rebalancing behavior is altered by asset-specific matching contributions and by restrictions on the trade of particular assets.

Chapter Three uses data from multiple panels of the Survey of Income and Program Participation to identify the effect of unemployment insurance benefits on household savings behavior. This chapter extends existing literature on precautionary savings and insurance to allow for the fact that insurance benefits are multi-dimensional, including replacement rates and benefit durations; incorporates additional econometric methods to accommodate the skewness and variation in household savings; allows for heterogeneous savings responses based on the likelihood of the insured risk through a two-step estimation procedure; and by allowing insurance benefits to affect the level and composition of assets by analyzing changes in the composition of the household's portfolio across assets that are likely (or unlikely) to represent precautionary savings. I find suggestive evidence of quantitatively large reductions in precautionary savings behavior in response to variation in both replacement rates and benefit durations, though these results are not statistically distinguishable from zero. The negative effect of benefit increases on savings is magnified for households at greater risk of unemployment, and for the households with below median levels of financial wealth, though again these results are statistically insignificant once standard errors are properly adjusted. These extensions do not provide enough power to detect savings responses to variation in insurance benefits at standard levels of confidence, despite point estimates that represent economically large responses.

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Introduction

Economists and policymakers have focused a great deal of attention over the years on household savings behavior. There are many examples of programs and subsidies that are explicitly designed to increase or otherwise alter household savings, and there is much literature on the effectiveness of these policies and the household's responses to various incentives within the plan.

The research in this thesis consists of three empirical studies that describe how households respond to various savings incentives. The first chapter discusses how households respond to tax benefits in 401(k) savings plans relative to their response to employer matching contributions. The second chapter looks at the allocation of 401(k) portfolios and household rebalancing behavior in the face of restrictions on trade and asset-specific matching contributions. The third chapter investigates how household savings behavior is altered by the presence of insurance, how these effects can differ across households, and how this can differ within the household's portfolio.

In the United States, 401(k) pension plans are savings vehicles that allow participating employees to save for retirement while avoiding taxation on both the initial wage income and the subsequent capital income accumulation. In exchange, the employee loses access to the savings in their 401(k) plan until they reach retirement age. 401(k) plans are largely sponsored by employers: often the employer further encourages employee participation in and contributions to the 401(k) plan by a variety of means. One of the most common examples is "matching". Employers can choose to match part or all of employee contributions to the 401(k) plan with additional funds.

The first chapter in this thesis analyzes the relative impact of the tax benefits and matching benefits in 401(k) savings plans on employee participation and contribution rates. While the matching and tax benefits are both designed to increase the attractiveness of saving within 401(k) plans, they encourage savings in very different ways. The matching benefits are straightforward: employee contributions are increased by the employer's matching contributions, and the account balance is immediately increased. The tax benefits are more subtle. Employees avoid initial taxation of 401(k) contributions, and receive a higher annual rate of return due to the tax free compounding of account assets. The bulk of the tax benefits depend on future rates of return, and are not realized in the savings account for an extended period of time. Given these differences (and many others), there is reason to believe that employees respond to these two incentives in different ways. Instrumental variables regression results show that employees increase participation rates in response to increases in matching and increases in tax rates, and that the increases in participation due to variation in tax rates is much larger than the increases due to match rates. This remains true once these effects are translated into changes in the internal rate of return of the 401(k) plan. Increases in tax rates also increase employee contributions conditional on participation, while increases in match rates have essentially no effect on conditional contribution behavior. Both of these mechanisms are designed to make 401(k) savings accounts more appealing to employees, though the tax deductibility of contributions and tax free compounding of plan assets seem to generate much larger behavioral responses than the match rate.

The second chapter in this thesis examines household portfolio choice behavior inside 401(k) plans. Matching contributions in 401(k) plans often are awarded in a particular asset (frequently the common stock of the employer), and these asset-specific matching contributions have restrictions on trade, known as "vesting" requirements, to prevent immediate trade of the matching contributions. In general, employees should prefer cash to the asset-specific match, particularly in the case of matching contributions in the common stock of the employer: an individual corporation's common stock is very volatile, much of that volatility can be diversified away with the purchase of an index, and, perhaps most importantly, the common stock of the employer is highly correlated with an employee's labor income. This chapter examines how employees adjust their contribution and rebalancing behavior in response to variation in vesting restrictions and the rate of employer matching in company stock. The empirical results suggest that employees are much more likely to rebalance their portfolio when vesting restrictions are lifted, they become even more likely to rebalance as match rates increase, and that the rebalance events consist of trades out of the employer's common stock. Employees also appear to adjust the allocation of their contributions in response to variation in the match rate: higher match rates are associated with a decrease in the probability that employees contribute to company stock. These results suggest that asset allocation constraints such as vesting requirements and asset-specific matching contributions significantly impact the portfolio behavior of employees within 401(k) plans.

In addition to policies designed to directly impact household savings such as 401(k) plans, there are many programs which alter savings incentives in more subtle ways. If households self-insure against future financial shocks, then the presence of insurance (and variation in the generosity of insurance) will change savings behavior. In the United States, the vast majority of employees are eligible for unemployment insurance benefits that are designed to help households smooth consumption in the event of a separation from the labor force. Unemployment insurance benefits are set annually in each state, and the resulting variation in the generosity of the insurance across otherwise similar households is one of the principal reasons why unemployment benefits are an appealing tool that can be used to assess the savings responses of households to insurance benefits.

The third chapter of this thesis explores household savings behavior in response to variation in unemployment insurance benefits. To the extent that households self insure against unemployment spells, increases in insurance generosity will lead to decreases in household capital accumulation. This chapter searches for evidence of this effect using variation in unemployment insurance benefits through the replacement rate and through the maximum eligible benefit duration across states and over time. This chapter also allows for household savings responses to vary with the likelihood of the insured risk by identifying households at relatively low and relatively high risk of unemployment based on observables. Finally, given that particular types of assets are more appealing for precautionary capital accumulation than others; this chapter allows households to save at different rates across asset types. These extensions provide qualitatively large but statistically insignificant estimates for the savings responses of households with respect to insurance benefits, which increase further amongst households at higher risk of unemployment.

Chapter 1

1 Match Rates, Marginal Tax Rates, and Retirement Savings

1.1 Introduction

In most developed countries, individuals have access to a variety of subsidized and tax advantaged retirement savings vehicles. Two common examples of such accounts in the United States are employer-provided 401(k) savings plans and Individual Retirement Accounts (IRAs). Both 401(k) plans and IRAs provide the individual with a means to defer taxation on capital accumulation (these accounts are often referred to as "Tax Deferred" accounts, or TDAs). These accounts, and 401(k) plans in particular, are a package of benefits that incorporate price distortions on several different margins.

Contributions to 401(k) accounts are often matched by employers up to certain limits, contributions are tax deductible up to certain limits, interest and capital gains are allowed to accumulate without taxation, and the assets that the household can purchase within the accounts are often restricted. There is a detailed existing literature on the effect of match rates on the amount, timing and composition of household savings inside and outside of these accounts, while there is substantially less known about the impact of the tax deductibility and tax free compounding on savings behavior. This is especially unusual as the tax deductibility and tax-free compounding of contributions have consequences for the government budget constraint in addition to the standard set of motives to increase retirement savings that are seen in the existing match rate literature.

Estimating the effects of tax deductibility on retirement savings places considerable demands on the data. In addition to accurately measuring the effects of match rates on savings behavior across employees, the data must include information on enough employees over enough time to contain meaningful, plausibly exogenous variation in marginal tax rates. Often, this variation can be found by comparing employees across states and years, but geographically and temporally diverse employees are generally exposed to variation in 401(k) plan rules and restrictions, which have a confounding influence on resulting empirical work. This paper utilizes data that can address these issues.

The information on participation and contribution behavior comes from a human resources dataset at a Fortune 500 company in the United States ("Company" hereafter), including detail on annual wages through the employee's W2 forms, demographic characteristics of the employee and their household, insurance elections, and the amount and composition of retirement savings. The Company offers different match rates to different employees, but offers the same core 401(k) plan to all employees. The variation in match rates allows for identification of the effects of employer matching on savings outcomes that can be grounded in the existing literature. Data on employees across states and over time allows for identification of the effects of marginal tax rates, and the homogeneity of plan rules and options across employees and over time avoids many of the potential confounding influences of nuisance variation in plan restrictions, portfolio selection, rebalancing rules, vesting rules, and loan availability. This paper utilizes this rich dataset and provides estimates of the effect of match rates and marginal tax rates on 401(k) participation and contribution rates, compares these estimates to one another based on the implied effect of annualized rates of return within the savings plan, and then calculates changes in wealth at retirement due to changes in match rates and marginal tax rates.

This paper is divided into six sections. The first section illustrates the effects of match rates and marginal tax rates on wealth at retirement. The second section describes the dataset used in the estimation procedure, including the details of the 401(k) savings plan. The third section characterizes the identification strategy and estimation equations. The fourth section contains the empirical results. The fifth section uses the empirical results to calculate of policy and parameter chances on retirement wealth. The final section concludes the paper and provides suggestions for future research.

1.2 Illustration of Benefits

Tax deductibility, tax free compounding, and employer matching contributions are designed to increase the implicit rate of return on savings for retirement. These benefits accomplish this objective in very different ways. The benefits from employer matching contributions are realized by the employee immediately. Their retirement contribution is increased by the matching percentage at the time of contributions (or shortly thereafter). In contrast, the bulk of the benefits from tax deductibility are due to the tax free compounding of annual returns as shown in Poterba (2004).

Employer matching contributions increase the retirement account balance at the moment of the contribution. An employee eligible for match rate m, that is saving for retirement T periods in the future, can expect $(1+m)(1+r)^T$ dollars at retirement for each dollar contributed today, where r is the annualized (for simplicity here a non-stochastic) rate of return. Holding all other effects fixed, the benefits of the 401(k) plan to the employee are always $(1+m)$: savings for retirement at a 100% match rate implies the employee has twice the account balance relative to a 0% match rate. That is, without the match, the agent will receive $(1+r)^T$ dollars at retirement, and the relative benefits of the matching on the marginal dollar saved can be expressed as:

$$B_{match} = \frac{\text{balance with match}}{\text{balance without match}} = \frac{(1+m)(1+r)^T}{(1+r)^T}$$

Which reduces to:

1. $B_{match} = 1 + m$

Tax deductibility and tax free compounding are more subtle. Employees that face a fixed marginal tax rate of τ receive some benefits today (through the time zero tax deductibility of their contributions), but the majority of the benefits are due to tax deferred compounding of returns. An employee saving the equivalent of one dollar after tax for retirement T periods in the future can expect

$$\frac{1-\tau_{ret}}{1-\tau}(1+r)^T$$

dollars at retirement. The $\frac{1}{1-\tau}$ represents the immediate tax deduction that the agent receives for the savings at time zero as it would take $\frac{1}{1-\tau}$ times as many taxable dollars outside of the tax-sheltered account to equal 1 dollar inside of the account. The $(1-\tau_{ret})$ term represents the taxation of the account upon withdrawal at retirement. In the absence of tax free compounding, the rate of return falls from $(1+r)^T$ to $(1+(1-\tau)r)^T$. Altogether, the change in the account balance at retirement due to tax deductibility and tax free compounding is:

$$B_{tax} = \frac{\text{balance with tax benefits}}{\text{balance without tax benefits}} = \frac{\frac{1-\tau_{ret}}{1-\tau}(1+r)^T}{(1+(1-\tau)r)^T}$$

Or,

2. $B_{tax} = \frac{1-\tau_{ret}}{1-\tau}[1 + \frac{r\tau}{(1+(1-\tau)r)}]^T$

Note that this amount depends on r and T, two parameters which were not present in the expression of benefits due to the match rate in equation (1).[1] Cases which allow lifecycle variation in marginal tax rates, stochastic rates of return, and endogenous withdrawal dates are more complex, but the form of the relative benefit calculations for

[1] Poterba (2004) provides a detailed walkthrough of these calculations in continuous time.

match rates and marginal tax rates remain very different. The benefits due to matching contributions are more predictable given the information available to the employee and are realized in the account at the time of investment; while the benefits due to favorable tax treatment depend greatly on the ultimate realizations of withdrawal dates, marginal tax rates, and rates of return, and are realized largely at future dates.

Combining the benefits due to matching and the benefits due to tax deductibility, the benefits of savings in an employer-matched 401(k) plan in terms of relative account balance upon withdrawal can be calculated as:

$$B_{401(k)} = \frac{\text{balance with plan}}{\text{balance without plan}} = \frac{\frac{1-\tau_{ret}}{1-\tau}(1+m)(1+r)^T}{(1+(1-\tau)r)^T}$$

3. $B_{401(k)} = \frac{\frac{1-\tau_{ret}}{1-\tau}(1+m)(1+r)^T}{(1+(1-\tau)r)^T}$

Table I contains sample calculations of these relative balances for some plausible values of *m, t, r,* τ and τ_{ret}. Small changes in the interest rate and time to withdrawal have substantial effects on the relative value of the tax benefits of saving in a 401(k) plan, while the additional benefits of matching contributions are fixed for all time and interest rate pairs. Matching contributions and tax deductibility are two ways that employees are encouraged to participate in retirement savings plans. Variation in match rates and marginal tax rates affect the relative benefits of retirement savings plans in very different ways. The goal of this paper is to estimate and compare the effects of marginal tax rates and match rates on employee participation and contribution behavior in employer-sponsored 401(k) plans, and the effects of variation in these two measures on employee wealth at retirement.

1.3 The Data

The data used in this paper is human resources and benefits data from a large, United States based corporation. The Company is a Fortune 500 enterprise in the manufacturing sector. The data includes information on employees such as their date of birth, tenure with the Company, wages (from W2 forms), gender, and location. Information on marital status and the number of dependents is inferred from health insurance elections made by the employee. Finally, the data also include information on the matching schedule available to each employee, the employee's own-money and total contributions to the retirement savings plan, and the allocation of their assets within the plan.

I analyze savings decisions by all salaried, full time, active employees who have at least one full year of information in the Company data. While there are more hourly workers than salaried workers at this firm, the salaried workers appear more homogenous across covariates and job descriptions. At the same time, there is more variation in incomes (and hence marginal tax rates) amongst salaried employees. The ultimate sample is a pooled cross section of 39,331 employee-years spanning 38 states during the years 2003-2006.

I compare outcomes across several different groups of employees. The identification of the effects of the match rate comes from two different match rates in the Company: 3,377 employee-years are offered a 50% match, and 35,954 are offered a 100% match rate. Note that all of the variation in match rates examined in this paper is on the intensive margin. There is evidence that the effects of savings incentives vary across the intensive and extensive margins (Papke and Poterba 1995; Papke 1995; Kusko, Poterba, and Wilcox 1994). As the relevant variation in marginal tax rates occurs on the intensive margin, comparisons of the effects of match rates and marginal tax rates resulting from this data are free of confounding effects resulting from comparing two substantively different types of variation.[2]

Table II contains summary statistics on the demographic composition of the sample of interest, and summary statistics on savings outcomes alongside similar information from independent data at the Employee Benefits Research Institute (EBRI). Employees that are offered a 50% match rate on average earn less than employees with 100% match rates and have worked for the firm for a shorter period of time. Compared to the independent EBRI sample, this data contains employees that are slightly older, have longer tenure at the firm, and have higher annual incomes.

1.4 Retirement Savings Plan Details

Each year, the Company distributes benefits information to employees. This includes a Summary Plan Description ("SPD") for the 401(k) plan. The SPD contains detailed information on the benefits of saving within the plan, including specific examples on the effect of tax deductibility on the employee's take home pay and plan savings, the associated pre-tax dollar limit for that year, and the relevant compensation limits from the Internal Revenue Service. Employees may enroll in the plan at any time by telephone or through the internet. Employees may then adjust, stop, or resume their pre-tax and after-tax contribution elections at any time via telephone or internet.

The investment options are clearly detailed within the SPD, including brief descriptions of each fund and the appropriate ticker symbol and website. In 2007, there were eleven funds that employees could choose from, as well as the Company's publicly traded common stock, and a self-directed brokerage plan through a third party organization. The 401(k) enrollment website also contains current and historical performance data for

[2] Of the 39,331 employee-year observations, only 83 (0.21%) have estimated marginal tax rates less than or equal to zero.

each security in the investment set. Dividends are automatically reinvested in the source fund. Employees may alter their contribution portfolio or their overall portfolio at any time, with the exception of matching funds that may only be transferred after a vesting period of two years or if the employee is over the age of 55, in which case they may be freely traded at any time.

In addition to match rates and marginal tax rates, 401(k) plans alter household savings incentives on many other dimensions. Importantly, while the match rate varies across employees, this is the only variation in plan details across employees: there are no differences in the investment opportunities, matching caps, tax deductibility limits, or enrollment procedures across Company employees. The maximum contribution rate that is eligible for a match, the maximum amount of tax deductible contributions, the assets available in the plan, the form of the match (Company stock), and the rules and restrictions governing loans and rebalancing are identical across all employees. For this reason, the Company uses the same core summary plan description for all employees. The restricted dimensionality of plan benefits within the Company reduces effects that omitted variables and jointly varying plan benefits could have when interpreting estimates of the effects of the match rate or marginal tax rate on savings behavior.

As the match rates vary within the Company, the general SPD states only that matching programs may be available. The SPD then explains the maximum percentage of salary that the Company will match, the form of the matching (Company stock), and the vesting rules for the matching funds. The employee's local human resources representatives then distribute a supplement to the SPD with information on that particular employee's match rate.

In the Company, match rates vary across four dimensions: the city and state of the workplace, whether or not the employee is hourly or salaried, the employee's subsidiary, and, amongst hourly employees, the employee's union status. Retirement benefits are selected by division heads with the requirement that the division report a given rate of return. Two salaried employees who work for the same subsidiary within the Company in neighboring cities may receive two different match rates. In practice, roughly one third of the states in the sample have within-state variation in the match rate offered to employees. In this sample, there is no within-employee variation in the offered match rates over time.[3] To be clear, it is often the case that different subsidiaries are the result of historical acquisition behavior by the firm. To the extent that the current employees in an acquired firm are similar to the employees at acquisition, the variation in match rates may be seen as across multiple firms, rather than within a single firm. That said, such a claim ignores the fact that all of the other savings plan details are identical across employees, and as such the variation in the match is free from several sources of confounding variation unlike a common across firm identification strategy.

1.5 Calculating Individual Marginal Tax Rates

The data contains employee observations across 38 different states for the years 2003-2006. As in Milligan (2002), Cunningham and Englehardt (2002) and Long (1990), the variation in marginal tax rates is across states and years. There are changes in the federal tax code during this time (largely relating to the income ranges within a given tax bracket), but the bulk of the variation in marginal tax rates is across states at a point in time.

The Company data provides a limited snapshot of total household labor earnings and capital income each year. The data informs the household's marital status based on their insurance elections, but provides no information on spousal or capital income. To obtain a more complete picture of household earnings, households are matched with

[3] It is not clear that variation within an employee over time is especially helpful as there is much inertia in retirement savings behavior. See Laibson, Madrian, Shea (2001).

similar households in the Current Population Survey ("CPS") and household capital and spousal income in the Company data are inferred from the CPS sample. Households in the Company data are organized according to their marital status, age and income decile, number of children, race, full time status, salaried status, state, year, and gender. These categories are matched to similarly constructed categories in the CPS. Individual earnings reported from the Company's W2 data are then scaled up by the relevant category-multiplier in the CPS to estimate total household labor income and total household capital income. This process turned individual labor income data into estimates of total household earnings and income. Once this information is obtained for the household, marginal tax rates are calculated using the National Bureau of Economic Research's TAXSIM program.

Table III contains statistics on the variation in match rates and federal and state marginal tax rates within and across states. Ten percent of the sample is offered a 50% match rate (3,377 observations), though this ten percent is distributed over 25 of the 38 states in the sample. Of those 25 states, 15 have a significant fraction (greater than 5%) of the employees assigned to a 50% matching plan. Those fifteen states contain 13,265 of the 39,331 employee-year observations (34% of the total). Much of the variation in marginal tax rates is due to differences in state income tax codes. On average, state tax rates average around 20-25% of the federal rates, though seven states have an average state marginal tax rate of zero. The seven states with no state income taxes contain 8,448 observations (21.4% of the total). The largest states in the sample are Pennsylvania (5,930 employee year observations), Texas (4,954), Indiana (3,739), Michigan (3,526), and Virginia (3,032).

1.6 Participation Rates and Contribution Rates

There are two main outcomes of interest in this paper: the employee participation rate in the 401(k) plan; and second, the employee's own-money contribution rate to the plan. The employee is defined as "participating" in the plan if they have positive own-money contributions in a given year. The employee's contribution rate is defined as the ratio of an employee's own-money contributions to their annual income for that year. [4]

The distinction between the extensive (participation rate) and intensive (contribution rate) margins is quite important. Increasing the match rates increases the value of marginal contributions to the plan which will act to increase savings through the substitution effect, but increases in the match rate also increase the present value of the agent's consumption, which will act to decrease savings through the income effect. For example, an increase in plan benefits may induce individuals who were previously not participating to begin contributions to the plan, but conditional on participation, the income effect of an increase in the match may dominate and conditional contributions may decrease.[5]

As noted in Table II, roughly 87% of employees within the Company contribute to the plan during any given year. Mean and median contribution rates conditional on participation lie between 6% and 7% of wage income, which corresponds to the matching cap of 6% put in place by the Company.

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[4] Without a restriction to own money contributions, there is a mechanical positive relationship between total contribution rates and match rates.

[5] Note that for individuals who contribute beyond the matching cap of 6% of annual income, any increase in match rates should unambiguously lead to a decrease in savings as there is no substitution effect at the margin.

1.7 Baseline Specification

I estimate several specifications: first, a simple model with no covariate controls; second, I incorporate flexible controls for ages, wages, tenure, and other demographic characteristics in the data; and finally, an instrumental variables approach to accommodate the endogeneity of individual marginal tax rates.

Specifications are of the following form:

4. $y_{ist} = x_{ist}\beta + \delta_t + \gamma_s + \varepsilon_{ist}$

Where y_{ist} denotes either: a dummy variable that equals one if employee i contributed to the 401(k) plan in state s in year t, or employee i's contribution rate in state s in year t. The match rates and/or marginal tax rates are denoted by the x_{ist}, δ_t are year fixed effects, γ_s are state fixed effects (where indicated), and ε_{ist} is the individual level innovation term.

The specifications in this paper can be thought of as a reduced form interpretation of the effect of match rates and marginal tax rates on retirement savings behavior. An alternative estimation strategy is a maximum likelihood estimation with non-linear budget set analysis. This involves constructing the intertemporal budget constraint for each household with each segment determined based on household contributions relative to the matching cap and their marginal tax rate, and then estimating the likelihood of a given household consuming on each segment of the budget set as a function of plan parameters, as in Hausman (1985). This approach is often applied to labor force participation as in Blomquist and Newey (1999). In this context, I prefer the reduced form methodology for two reasons: the resulting coefficients are the relevant values for policy interventions involving the parameters of interest, and the bulk of the existing literature on the effects of the match rate on retirement savings employs a similar reduced form approach. That said, estimation with non-linear budget sets is a valid alternative that is beyond the scope of this paper.

1.8 Simulated Instruments and Identification

Individual marginal tax rates cannot be used to obtain unbiased estimates of the effect of tax benefits on participation and contribution rates. Not only are individual marginal tax rates influenced by individual characteristics that are correlated with savings behavior, they also reflect state-specific variation in earnings. This endogeneity is dealt with through a simulated instruments approach that is similar to Currie and Gruber (1997). For each year, a national sample is run through the tax code for each state. The marginal tax rates faced by each household are calculated under the rules for that state. The resulting rates are then averaged by state and year. This state-year average is the instrument for individuals who reside in that state-year pair. This process purges the marginal tax rate measure of potentially confounding individual information that may bias the estimated coefficients, as well as any state-specific distributional concerns as the instrument is based on the marginal tax rates faced by a national sample under the rules of each state. The resulting simulated instrument varies only through the variation in tax laws between states over time: all individual level variation has been removed.

After the simulated instruments process, the identification of the marginal tax rate coefficient is solely at the state and year level. The exclusion restriction in these specifications is that the general level of tax rates in a particular state and year do not impact employee 401(k) savings, except through their effects on the tax deductibility and tax free compounding of those contributions. This restriction requires no income effects from taxation. For example, increases in the level of tax rates in a given state can decrease net household wages, which can decrease current and future consumption levels. If such changes in consumption levels over time due to changes in tax rates and tax policy lead to changes in household savings behavior, the tax rates resulting from the simulated instruments procedure may still fail to identify the desired effects.

Identification of the effect of match rates on savings behavior in equation (4) relies on the exogenous assignment of match rates within the Company. Again, match rates are chosen for participating employees by division heads, and the unit of variation for match rate assignment in the sample of interest is the location-subsidiary pair. The identification strategy for the effect of the match rates will fail if match rates were historically assigned because of persistent differences in preferences for retirement savings amongst different groups of employees that happen(ed) to separate on location-subsidiary pairs. While the exclusion restriction is not directly testable, it is possible to compare the observable characteristics of employees across match rates. Recall the summary statistics in Table I. The employees with a 100% match rate appear to have higher wages, and appear to have worked slightly longer for the Company. I attempt to accommodate for these differences with flexible non-linear income and tenure controls in various specifications. Again, the 401(k) plan details across employees are identical except for the match rates: at best, match rates are exogenously assigned within the firm, while at worst, match rates vary across subsidiaries such that the identifying variation for match rates is across firms with otherwise identical retirement savings plans.

Match rates do not vary within employees in this data unless the employee has either left the sample entirely, or otherwise changed their location-subsidiary pair that determines individual match rates. It is straightforward to identify the effect of marginal tax rates on retirement savings by exploiting the variation in tax rules across both states and years, but the variation in match rates is largely across employees (states) at point in time. The variation in the match rate within states over time is due to the entry, transfer, and exit of employees, which may be substantively different than the variation in match rates across employees (states) at a point in time. To address this issue, I estimate the effect of match rates on retirement savings behavior using the variation across states at a point in time with year fixed effects alone, and the impact of marginal tax rates is estimated separately with both state and year fixed effects. I also include a specification that simultaneously estimates the effects of match rates and marginal tax rates using both state and year controls.[6]

1.9 Participation Rates

Again, the estimation equation is of the following form:

4. $y_{ist} = x_{ist}\beta + \delta_t + \gamma_s + \varepsilon_{ist}$

Where y_{ist} is a binary variable equal to one if the employee contributed to the 401(k) plan during the year, x_{ist} denotes the match rates and/or marginal tax rates, δ_t are year fixed effects, γ_s are state fixed effects (where indicated), and ε_{ist} is the individual level error term. Standard errors are clustered at the state level for all specifications. These specifications are Column I and Column III in Table IV.[7]

The second specification can be expressed as follows:

5. $y_{ist} = x_{ist}\beta + z_{ist}\alpha + \delta_t + \gamma_s + \varepsilon_{ist}$

Where all variables are defined as in equation (4), and z_{ist} are flexible covariate controls. These include: dummies indicating the employee's decile of the distribution of age and tenure, dummies for the employee's ethnicity, gender, pension availability, marital

[6] If preferences for retirement savings vary systematically across states, then the specification with both state and year dummies will provide consistent estimates of the effect of marginal tax rates, while the specification with only year fixed effects will not. Similarly, if the residual within state variation in the match rate is from employees systematically moving between locations due to variation in their retirement savings preferences, then the specification that does not include state fixed effects will remain consistent, while the specification with both state and year controls will not.

[7] I also estimate a Probit model for participation (see Table IV.2). The marginal effects from Probit estimation are statistically indistinguishable to those in the OLS specification. Contribution rates are estimated conditional on participation.

status, as well as a five knot cubic spline in labor income. Flexible controls for age, tenure, and wages are important given their effects on retirement savings decisions and the possible differences in the sample across match rates as seen in Table I: several different functional forms were tested with no substantive change in the estimated coefficients. This estimation can be found as Columns II and Column IV in Table IV. Coefficients on selected covariates are reported in Table IV.2.

Finally, I estimate the effect of marginal tax rates on participation by incorporating the instrumental variables strategy discussed in the previous section to account for endogeneity in individual tax rates.

6. $y_{ist} = \hat{x}_{ist}\beta + z_{ist}\alpha + \delta_t + \gamma_s + \varepsilon_{ist}$

This specification uses a simulated instrument approach, as previously discussed, to calculate the effect of marginal tax rates ($\hat{x}$). This specification can be found in Column V and Column VI in Table IV. In Column VI, the effect of the match and marginal tax rates are estimated simultaneously.

The estimated coefficients for the effect of the match rate are stable and statistically indistinguishable across specifications with and without state fixed effects and with and without the simultaneous inclusion of marginal tax rates (0.00073 without state fixed effects and without marginal tax rates in Column II, 0.00754 without state fixed effects and with marginal tax rates in Column VI, and 0.00066 with state fixed effects and with marginal tax rates in Column VII). This suggests that the residual variation in match rates within states over time is substantively similar to the variation across states at a point in time, despite the possible differences in the identifying variation. That said, the institutional details regarding match rate assignment across employees in the Company are such that the natural source of variation in match rates is across locations at a point in time. Given this fact, the preferred specification identifies the effect of the match without state fixed effects (Column II and Column VI). The point estimates from

Column II will be used in the remainder of this paper, though the ultimate wealth calculations change very little if the simultaneously estimated coefficients that include both state and year fixed effects (Column VII) are used instead.

The estimated effects of marginal tax rates are larger in absolute value than the estimated effects of the match rate. In Column VII of Table IV, a 10 percentage point increase in marginal tax rates increases participation rates by about 11 percentage points (13.5% of the mean participation rate), and a corresponding 10 percentage point increase in the match rate increases participation rates by 0.6 percentage points (0.7% of the mean). Effects of this magnitude are comparable with the estimated effects of marginal tax rates in Milligan (2002), where a 10 percentage point increase in marginal tax rates increases participation rates in Canadian Tax Deferred Accounts by 8%. The estimated impact of match rates on employee participation (0.73 percentage point increase in participation with a ten percentage point increase in the match rate) is also broadly consistent with the estimates in the existing literature as well. In Papke and Poterba (1995), a change from a 50 percent match rate to 100 percent match rate is associated with an increase in participation rates of 4.8 percentage points (0.96 percentage points for a ten percentage point change). In Papke (1995), a change in the match rate from 50 to 100 percent corresponds to a 7.3 percentage points increase (1.46 percentage points in for a ten percentage point change). The effect of a one percentage point change in marginal tax rates on participation is over ten times larger than the effect of a similar change in match rates. The difference between the two coefficients is statistically significant at any reasonable level of confidence. The coefficients on marginal tax rates do not change if they are estimated simultaneously with the effects of match rates. However, the absence of state fixed effects substantively alters the estimated coefficient on marginal tax rates (Column VI versus Column VII of Table IV). This suggests that the specifications without state fixed effects yield biased estimates for the effects of marginal tax rates.[8] Given this fact, the preferred specifications for the effect of marginal tax rates are the instrumental variables specifications that include state fixed effects (Column V and Column VII). The point estimates from Column V will be used later in the paper to determine the effects of changes in marginal tax rates on wealth at retirement. These calculations change very little if the coefficient that is simultaneously estimated with match rates from Column VII is used instead.

The coefficients on selected covariate controls for the above specifications are presented in Table IV.2. Contribution rates increase with tenure and income, and white, married households appear more likely to participate in employer sponsored 401(k) plans.[9]

1.10 Contribution Rates

The next issue of interest is to quantify changes employee contribution rates corresponding to changes in match rates and tax rates. In this section, I replace the binary measure of contribution behavior used in the participation rate specifications with the employee's annual contribution rate, measured as the ratio of own-money contributions to the 401(k) plan to annual employee wages as listed on their W2 forms. I estimate equations (4), (5), and (6) using the employee's annual contribution rate as the outcome variable of interest. Specifications estimating the effect of the match rate and/or marginal tax rates on employee contribution rates are estimated on the subsample of 34,218 participating employees. These specifications are included in Table V.

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[8] This is consistent with differences across states in preferences for savings that is correlated with the marginal tax rates in the states, such as alternative state programs designed to encourage savings. The relevance of state fixed effects in tax rate specifications is well documented.

[9] Tenure and age are highly correlated. The net impact of a change in tenure category and the corresponding mean change in age decile is positive.

The estimated effects of the match rate on contribution rates conditional on participation are negative and statistically indistinguishable from zero in every specification (-0.000011 in Column II of Table V, -0.000020 in Column VI of Table V, and -0.000016 in Column VII of Table V). These results are consistent with small, insignificant (and often negative) effects of intensive margin increases in match rates on contribution behavior documented in Papke (1995) and Papke and Poterba (1995). Column V, Column VI, and Column VII show the estimated effects of marginal tax rates on contributions are positive and significant. Once again, the instrumental variables specifications with state fixed effects result in statistically identical point estimates if estimated individually or estimated simultaneously with the effects of the match rate (Column V and Column VII). The marginal tax rate coefficients in Column V and Column VII suggest that a 10 percentage point increase in marginal tax rates increases contribution rates by 1.5 percentage points (21% of the mean contribution rate of 7%). While there are no directly comparable estimates in the literature, Cunningham and Englehardt (2002) find that the introduction of tax deductibility into retirement savings accounts increases contribution rates by 6 percentage points. In this dataset, the analogous calculation would be a 24.16 percentage point increase in marginal tax rates (the average combined federal and state tax rate in the data), which corresponds to an estimated 3.69 percentage point increase in contribution rates. The inclusion of covariate controls in Columns II, IV, V, and VII slightly decrease the effects of marginal tax rates and match rates. In particular, the coefficients on marginal tax rates are particularly sensitive to the inclusion of information on age and income. [10]

For the wealth effects that follow, I use the estimated effects of match rates identified across states in Column II of Table IV and Table V for reasons discussed at the outset. However, these calculations change little instead the jointly estimated effects with both state and year fixed effects from Column VII are used. For marginal tax rate

[10] Given that marginal tax rates are an explicit function of income, changes in the marginal tax rate coefficient with the inclusion of income controls is to be expected.

calculations, the effects of marginal tax rates on savings behavior identified within states in Column V of Table IV and V is preferred. Using the specification that includes match rates and both state and year fixed effects (in Column VII) does not substantively change the marginal tax rate calculations that follow.

1.11 Comparing the Effects of Match Rates and Marginal Tax Rates on Savings

One explanation for the differences in sign, significance, and magnitude between the estimated effects of marginal tax rates and match rates is the relevance of income effects. Half of the sample contributes beyond the matching cap. For these employees, further increases in match rates have no substitution effect. Given this fact, it seems more likely that the income effect of changes in the match will dominate the substitution effect (and thus equation (6) will yield a negative point estimate for the effect of match rate). In contrast, essentially every employee in the sample is exposed to tax deductibility at the margin, so the substitution effect remains relevant for many more individuals. [11]

Another explanation for the different effects of match rates and marginal tax rates can be in the form of the incentives themselves. As discussed at the outset, the benefits to the employee from matching contributions and tax deductibility are substantially different. Employer matching contributions are made in Company stock, which cannot be divested for a period of two years, whereas the benefits from tax deductibility are realized in cash. With this view, the coefficient on match rates is an underestimate (in absolute value) of the true effect of matching contributions when measured in the same assets as the effects of tax benefits. Indeed, Muelbrook (2002) estimates the value of a match in Company stock versus a match paid in cash at roughly fifty cents on the

[11] There are 42 employee-year observations out of 34,218 that contribute beyond the tax deductibility cap.

dollar, but any such calculation is complicated by the revealed preference of the employees in the sample: recall from Table I that roughly 46% of employees contribute some of their *own* savings to the Company's common stock above and beyond the automatic matching contributions. For these individuals, any such correction is inappropriate. [12]

Despite this, some adjustment is necessary to properly compare the effects of marginal tax rates and match rates. The benefits of tax deductibility and tax free compounding on retirement wealth increase over time, as they largely manifest through increases in the annualized rate of return. Changes in the match rate have fairly flat effects on retirement wealth over time, while the effect that the match rate has on the internal rate of return on 401(k) contributions relative to savings outside of the 401(k) plan increases over time: eventually, employees can contribute to the account, recover the matching contribution, and immediately withdraw their original funds and the matching contributions. [13]

A one percentage point increase in tax rates has a different impact on the relative value of the 401(k) savings plan than a one percentage point change in the match rate, and these effects change over time. To better compare the estimates in Table IV and Table V, I calculate the effect of a one percentage point change in match rates and marginal tax rates on the *spread* between the annualized internal rate of return of contributions to the Company sponsored 401(k) plan and an external savings vehicle with neither tax advantages, nor matching contributions for a variety of parameterizations for age, real interest rates, and marginal tax rates. I use the point estimates from Table IV and Table V along with equation (3) to calculate the change in this 401(k) "spread" through changes in either the marginal tax rate or the match rate for these parameterizations. I calculate:

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[12] The estimates in Muelbrook are especially difficult to reconcile with individual behavior given the findings in Benartzi (2001) that own-money contributions to company stock tend to *increase* when employer matching contributions are made in company stock relative to cash.
[13] Even employees that are eligible to immediately withdraw matching contributions have less than 100% participation rates. See Choi, Laibson, and Madrian (2005).

$\frac{dB_{401(k)}(m,\tau,r,age,T)}{dm}$ and $\frac{dB_{401(k)}(m,\tau,r,age,T)}{d\tau}$, where

$$3.\quad B_{401(k)} = \left[\frac{\frac{1-\tau_{ret}}{1-\tau}(1+m)(1+r)^{T-age}}{(1+(1-\tau)r)^{T-age}}\right]^{\frac{1}{T-age}}$$

The results of these calculations for match rates are included in Table VI and results for marginal tax rates are included in Table VII. Entries in the table represent the effect of a 10 percentage point increase in the match rate and the marginal tax rate at the specified rate of return, age, baseline match rate, and baseline marginal tax rate on the annualized spread of the 401(k) plan as measured by changes in equation (3).

The annualized spread in Table VI decreases as the baseline match rate increases, and increases (slightly) as marginal tax rates increase. Increases in the match rate are more valuable in terms of changes in the annualized spread when the initial match rate is low. The relatively large impact of the match rate on the annualized spread at low levels of the match is consistent with estimates from Papke (1995) and Papke and Poterba (1995) that find increases in the match rate when the match is near zero have much larger effects on savings and participation rates than increases in the match when the match is near one. The value of changes in the match rate increases with age, and the rate of return on investment has no impact on the value of changes in the match, unless the employee is also receiving tax benefits. The change in the annualized spread due to changes in marginal tax rates (Table VII) increases with increases in both the baseline match rate and the baseline marginal tax rate. Increases in the spread due to increases in marginal tax rates are higher when the match rate and the marginal tax rate are already high. As the benefits from tax deductibility accrue over time through tax free compounding, the gains due to changes in the marginal tax rates decrease with age and increase with the rate of return on investment. At the mean values of age and marginal tax rate in the sample (45 years and 25%, respectively) and an annual rate of return on investment of 3 percent, a change in the match rate is slightly more valuable (in terms of the annualized 401(k) spread) than the change in tax rates for employees with a 50% match (0.0342% for the match versus 0.0302% for the tax rate), while the situation is reversed for employees with 100% match rates (0.0260% and 0.0306%).[14]

The point estimates in Table IV and V can be applied to these values to see the response of 401(k) participation and savings rates to changes in the rates of return induced by changes in marginal tax rates and match rates. In Column II of Table IV, we found that a one percentage point increase in the match rate led to a 0.073 percentage point increase in participation rates, while a one percentage point increase in the marginal tax rate from Column V of Table IV led to a 1.43 percentage point increase in participation rates. For employees with a 100% match rate, the one percentage point increase in the match is a 0.0260 percentage point increase in the annualized spread of the 401(k) plan, and a one percentage point increase in the marginal tax rate is a 0.0306 percentage point increase in the value of the 401(k) plan. Combining these values, the change in participation rates per basis point of change in value of the 401(k) plan due to changes in the match rate is 2.81 for employees with 100% match rates (SE: 1.10); while the change in participation rate per basis point of change in value due to changes in the marginal tax rate is 50.72 (SE: 6.17). Employees seem much more responsive to changes in the marginal tax rate than to changes in the match rates, even when the two incentives are translated into the implied impact on the relative value of the 401(k) plan. In Column II of Table V, the change in contribution rates conditional on participation due to changes in the match rate is -0.0011 percentage points, while the change in contribution due to changes in the marginal tax rate from Column V of Table V is 0.154 percentage points. Again, the effects of the match rate and marginal tax rate on annualized rate of return at the mean values of age and tax rates in the sample are 0.0260% and 0.0306% for match rates and marginal tax rates respectively. This implies that the change in contribution rates per basis point change in value of the 401(k) plan due to changes in the match rate is -0.0423 (SE: 0.196), while the change in contribution

[14] With an annualized rate of return of 7 percent, the value of changes in the marginal tax rate is greater than the value of changes in the match rate for employees receiving 50% or 100% match rates.

rates per basis point change in value due to changes in the tax rate is 5.04 (SE: 0.546), over one hundred times larger in absolute value. Together, these calculations suggest that after adjusting match rates and marginal tax rates for their impact on the relative value of the 401(k) plan, employee participation and contribution behavior is still more responsive to changes in the marginal tax rate than to changes in the match rate.

1.12 Effects on Wealth at Retirement

The effects of match rates and marginal tax rates on the relative value of the 401(k) plan through annualized rates of return differ substantially. Often, the relevant outcome for policy intervention is the effects of changes in the match or in tax rates on the employee's total accumulated wealth at retirement. This calculation requires the estimated effects on participation and contribution rates simultaneously.

An employee's total wealth at retirement if they do not have access to matching benefits, tax deductibility, or tax free compounding can be expressed through the following relationship:

7. $W_T = (1 - \tau_{ret}) \sum_{s=0}^{T} \left[c_s \prod_{j=s}^{T} [1 + r_j (1 - \tau_j)] \right]$

Where τ_s is the employee's marginal tax rate at time s, τ_{ret} is the marginal tax rate at retirement, c_s is the employee's contributions at time s (in after-tax dollars), and r_s is the annualized interested rate earned on the portfolio at time s. The presence of matching contributions and tax benefits change the relationship to:

8. $\widetilde{W}_T = (1 - \tau_{ret}) \sum_{s=0}^{T} \left[\frac{1}{1-\tau_s} c_s (1 + m_s) \prod_{j=s}^{T} [1 + r_j] \right]$

Where m_s is the match rate offered to the employee at time s, and all of the other variables are defined as before.

Changes in wealth at retirement due to changes in plan parameters occur through two separate channels: first, there is the mechanical effect on W_T (the partial derivative of the expression above); second, changes in plan parameters impact the size of an employee's contributions, c_s (and the associated partial derivative above). [15] That is, changes in retirement wealth can be decomposed into:

$$9. \quad \frac{d\widetilde{W}_T}{dx_s} = \left(\frac{\partial \widetilde{W}_T}{\partial x_s} + \frac{\partial \widetilde{W}_T}{\partial c_s}\frac{\partial c_s}{\partial x_s}\right)$$

Where x_s is the parameter of interest (m_s or τ_s). Of the three expressions on the right side of the equality, the non-mechanical relationship is $\frac{\partial c_s}{\partial x_s}$, which was estimated in the previous section. This decomposition allows for the evaluation of changes in match rates and marginal tax rates in terms of their effects on wealth at retirement for various households.

1.13 Changes in Wealth at Retirement: Matching Contributions

In the last decade, there has been much debate about ways to increase retirement savings amongst low and middle income families (Duflo, Gale, et al 2005). One of the most common suggestions is to "match" retirement contributions to IRA and 401(k) accounts via federal tax credits, or the creation of separate retirement savings accounts, or "RSAs" that incorporate this sort of matching scheme.[16] The point estimates in this

[15] Note: the empirical estimates in the previous section and the existing literature suggest that $\frac{\partial c_s}{\partial x_s}$ differs if $c_s = 0$ or if $c_s > 0$. If $c_s = 0$, the relevant value is the effect on participation, and if $c_s > 0$, the desired estimate is the effect on contributions conditional on participation.

[16] The June 2, 2009 version of the federal budget of the United States of America includes provisions that dramatically expand the current "Saver's Credit" through refundability of existing tax credits and an increase in the income thresholds. These changes collectively make the program look behave much like a matching scheme for many more households.

paper allow us to calculate the effect that such proposals will have on wealth at retirement.

For example, consider the introduction of a federal match rate of 50% on retirement savings. Such a policy will have three effects on retirement wealth: the match rate will mechanically increase the wealth of future retirees by up to 50%; the presence of the match will alter the number of people who participate in the savings accounts; and the presence of the match will alter the contribution rates of individuals who participate in these accounts. Equations (7) and (8) can be used to calculate these changes. From equation (8):

10. $\frac{\partial \widetilde{W}_T}{\partial m_s} = (1 - \tau_{ret})\left[\frac{1}{1-\tau_s} c_s \prod_{j=s}^{T}[1 + r_j]\right]$, and

11. $\frac{\partial \widetilde{W}_T}{\partial c_s} = (1 - \tau_{ret})\left[\frac{1}{1-\tau_s}(1 + m_s)\prod_{j=s}^{T}[1 + r_j]\right]$

And from our point estimates in Column II of Table IV and Table V, we have:

$$\frac{\partial c_s}{\partial m_s} = -0.000011 I_s \; for \; c_s > 0$$

$$\frac{\partial(1\{c_s > 0\})}{\partial m_s} = 0.000733$$

For changes in conditional contribution rates and participation rates respectively (with I_s representing wage income at time s). Given a path for real interest rates, income, and tax rates for the household, it is possible to calculate the changes in wealth at retirement due to existing matching contributions and tax advantages, and due to the incremental changes in wealth through the increase in match rates as discussed above.

Baseline Benefits + Change in Benefits =

$$\left.\frac{\widetilde{W}_T}{W_T}\right|_{c_s>0} \Pr(c_s > 0) + \left.\frac{\frac{d\widetilde{W}_T}{dm_s}\Delta m_s}{W_T}\right|_{c_s>0} \Pr(c_s > 0|\Delta m_s) =$$

$$= \frac{\sum_{s=0}^{T}\left[\frac{1}{1-\tau_s}c_s(1+m_s)\prod_{j=s}^{T}[1+r_j]\right]+\left[\frac{1}{1-\tau_s}\left((1+m_s)\frac{\partial c_s}{\partial m_s}+c_s\right)\prod_{j=s}^{T}[1+r_j]\right]\Delta m_s}{\sum_{s=0}^{T}\left[c_s\prod_{j=s}^{T}[1+r_j(1-\tau_j)]\right]}$$

This calculation is done in Panel I of Table VIII. [17]

Several patterns emerge. First, the increases in wealth at retirement due to the introduction of general matching increase as the age of the household decreases, as the rate of return on investment increases, and as the marginal tax rate increases. The increases with age are particularly pronounced: both the existing effects of the marginal tax rate (Panel II) and the incremental effects of changes in the match rate (Panel III) increase for younger households. This suggests that the effectiveness of matching -type savings incentives is dependent on the length of time the benefits can be realized by the household, as well as the realized values of interest rates. Second, the incremental benefits due to changes in the match rate (Panel III) are between one-quarter and one-third of the total change in wealth, depending on the age of the household. This is primarily due to the mechanical effect of the matching funds, as the induced effect of the match rate on contributions (Panel IV) only represents a small fraction of the gains in total wealth. Six to eight percent of the incremental changes in wealth (two to five percent of the total changes in wealth) at retirement are due to induced changes in contribution and participation rates resulting from the increase in match rates. Introducing or increasing match rates increases wealth at retirement primarily through the functional relationship between match rates and future wealth, rather than through changes in household savings behavior.

[17] Note that $\frac{\partial c_s}{\partial m_s}$ has two values based on the value of c_s with and without the plan: If c_s is positive with and without the change, $\frac{\partial c_s}{\partial m_s}$=$-0.000011 I_s$; if c_s is positive with the change and zero without the change, $\frac{\partial c_s}{\partial m_s}$=$0.000733\overline{c_s}$, where $\overline{c_s}$ is the average contribution amount amongst plan participants.

Obviously, if c_s is zero in either case, $\frac{\partial c_s}{\partial m_s}$=0.

1.14 Changes in Wealth at Retirement: Marginal Tax Rates

While raising taxes is not a policy designed to encourage savings, the effect of changes in marginal tax rates on savings behavior within retirement and other tax advantaged accounts is of interest. This is especially true at the present, as there are likely to be revisions to the federal tax code in the coming years.[18] The estimates in Table IV and Table V allow for the calculation of the effect of tax changes on wealth at retirement through an expansion as in equation (9).

The mechanical effect that an increase in marginal tax rates will have on retirement wealth can be seen in equation (8):

12. $\frac{\partial \widetilde{W}_T}{\partial \tau_s} = (1-\tau_{ret})\left[\frac{1}{(1-\tau_s)^2} c_s(1+m_s)\prod_{j=s}^{T}[1+r_j]\right]$

Again, $\frac{\partial \widetilde{W}_T}{\partial c_s}$ is defined by equation (11). From the point estimates in Column V of Table IV and Table V:

$$\frac{\partial c_s}{\partial \tau_s} = 0.00154 I_s \; for \; c_s > 0$$

$$\frac{\partial(1\{c_s > 0\})}{\partial \tau_s} = 0.0143$$

Table IX contains the impacts on wealth at retirement of increasing tax rates.

The cells contain calculations for the baseline effect of the savings plan through matching and tax deferred growth, as well as the incremental changes in wealth in the tax-advantaged account due to an increase in tax rates of 3 percentage points. As before, the changes in wealth are benchmarked against the wealth that the employee

[18] Current proposed revisions include: rolling back tax credits enacted in 2001, tax surcharges to fund health care expansion, increases in taxes to fund intervention in financial markets, and so on.

could otherwise accumulate outside of the account. Total changes in wealth (in Panel I) are defined as:

Baseline Benefits + Change in Benefits =

$$\left.\frac{\widetilde{W}_T}{W_T}\right|_{c_s>0} \Pr(c_s > 0) + \left.\frac{\frac{d\widetilde{W}_T}{d\tau_s}\Delta\tau_s}{W_T}\right|_{c_s>0} \Pr(c_s > 0|\Delta m_s) =$$

$$= \frac{\sum_{s=0}^{T}\left[\frac{1}{1-\tau_s}c_s(1+m_s)\prod_{j=s}^{T}[1+r_j]\right] + \left[\left(\frac{c_s}{1-\tau_s}+\frac{\partial c_s}{\partial \tau_s}\right)\frac{(1+m_s)}{1-\tau_s}\prod_{j=s}^{T}[1+r_j]\right]\Delta\tau_s}{\sum_{s=0}^{T}\left[c_s\prod_{j=s}^{T}[1+r_j(1-\tau_j)]\right]}$$

Where $\frac{\partial c_s}{\partial \tau_s}$ again has two values based on the sign of c_s with and without the incremental policy intervention as depicted above.

Young households receive the preponderance of the benefits from changes in marginal tax rates, though the age-benefits profile here is much less pronounced than it was for changes in the match rates. The extra wealth at retirement due to additional contributions induced by tax changes is roughly half of the total additional wealth at retirement from the tax increase (Panel IV/Panel III) across the various values for household age and rate of return, compared to 6 to 8 percent for match rates. Changes in marginal tax rates alter wealth at retirement in large part due to the effects of the changes on savings behavior, while changes in match rates appear to impact wealth at retirement primarily through the mechanical effect of the match on wealth. This is consistent with the empirical results in the previous section that illustrate the effect of tax rates on contribution and participation behavior is much larger than that of match rates.

1.15 Conclusion

This paper utilized a unique dataset from a Fortune 500 corporation in the United States to compare the effectiveness of tax benefits and matching contributions as savings incentives. The only variation in plan details amongst participating employees within the firm is the match rate that they are offered. Vesting requirements, available assets, matching caps, loan provisions, and the logistics of account management are identical across all employees. This variation allows for identification of the effects of match rates on participation and contribution rates. The data spanned several states and years, which allowed for identification of the effects of tax rates through a simulated instruments approach as in Currie and Gruber (1997).

The estimated effects of increases in matching contribution on participation and savings behavior are consistent with existing literature: increases in the match rate on the intensive margin lead to small increases in participation rate, and small (statistically insignificant) decreases in participation rate (Papke (1995); Papke and Poterba (1995); Kusko, Poterba, and Wilcox (1994)). The estimates for the effects of the tax rate are without direct comparison, though the sign and magnitude of the effects on participation rates are consistent with point estimates of the effects of taxation in other contexts (Long (1990); Milligan (2002); Cunningham and Engelhardt (2002)). Marginal tax rates have large, significant effects on employee participation and contribution behavior in 401(k) plans. These results are robust to joint and individual estimation, as well as a flexible array of controls and covariates.

The empirical estimates are translated into implied changes in the internal rate of return that a 401(k) plan offers the employee. For a given change in the annualized rate of return, match rates and marginal tax rates have substantially different effects on participation and contribution behavior. The difference between changes in tax rates and match rates on savings are particularly striking in this light: when measured in terms of changes to the internal rate of return of the 401(k) plan, employees are over fifteen times more responsive to variation in the marginal tax rate compared to variation in the match rate on the participation margin. The difference on the contribution margin is even larger.

Finally, the estimates are used to evaluate the effects of changes in match rates and marginal tax rates on wealth at retirement within 401(k) accounts: the introduction of a general "top up" matching scheme with a 50% match rate, and a fixed three percentage point increase in tax rates. These calculations accommodate endogenous changes in participation rates and contribution rates as plan parameters change according to the estimates in the paper. The change in match rates leads to an increase in participation rates, small decreases in contribution rates conditional on participation, and an increase in the relative value of the retirement account. Much of the effects due to changes in match rates are due to the matching funds themselves, with little additional wealth from induced participation and contribution behavior by households. In contrast, the tax increase leads to an increase in the relative value of the retirement plan through an increase in both participation and savings rates. Nearly half of the additional wealth at retirement under the tax simulation is due to increases in contribution and participation rates rather than the mechanical value of the subsidy.

Future areas for research on this topic include explanations why these two incentives have such different impacts on savings behavior. Behavioral effects, such as time inconsistent preferences as in Benartzi and Thaler (2004); Laibson (1998); Diamond and Koszegi (2000), and/or errors in household optimization as in Duflo and Saez (2002); Benartzi (2001); Choi, Laibson, Madrian, and Metrick (2002) may help account for some of these differences. In addition to explanations into why the differences in behavior occur, there are alternative ways to estimate the effects of match rates and marginal tax rates on savings. There is little in the existing literature on the effects of match rates on savings similar to the non-linear budget sets analysis seen in the literature on labor force participation and taxation. The effects of match rates and marginal tax rates on retirement savings behavior seem like a natural application of the non-linear budget sets approach.

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Tables

Table I: Relative Effects of Tax and Matching Benefits in 401(k) Accounts

		$m=0.5, \tau=\tau ret=0.15$							
		Tax Benefits Alone				Total Benefits			
	Annual Interest Rate	0.03	0.05	0.07	0.10	0.03	0.05	0.07	0.10
Years to Withdrawl	10	1.04	1.07	1.10	1.15	1.57	1.61	1.66	1.72
	20	1.09	1.15	1.22	1.32	1.64	1.73	1.83	1.97
	30	1.14	1.24	1.34	1.51	1.71	1.86	2.02	2.26
	40	1.19	1.33	1.48	1.73	1.79	2.00	2.23	2.60
		$m=0.5, \tau=\tau ret=0.25$							
		Tax Benefits Alone				Total Benefits			
	Annual Interest Rate	0.03	0.05	0.07	0.10	0.03	0.05	0.07	0.10
Years to Withdrawl	10	1.08	1.13	1.18	1.26	1.61	1.69	1.77	1.89
	20	1.16	1.27	1.39	1.58	1.74	1.91	2.09	2.38
	30	1.25	1.43	1.64	1.99	1.87	2.15	2.46	2.99
	40	1.34	1.61	1.93	2.51	2.01	2.42	2.90	3.76
		$m=0.5, \tau=\tau ret=0.35$							
		Tax Benefits Alone				Total Benefits			
	Annual Interest Rate	0.03	0.05	0.07	0.10	0.03	0.05	0.07	0.10
Years to Withdrawl	10	1.11	1.18	1.26	1.38	1.66	1.77	1.89	2.07
	20	1.23	1.40	1.59	1.91	1.84	2.10	2.38	2.86
	30	1.36	1.66	2.00	2.64	2.04	2.48	3.01	3.96
	40	1.51	1.96	2.53	3.65	2.26	2.94	3.79	5.47

Source: Author's Calculations

Cells contain the relative value of a dollar invested in a 401(k) account to a dollar invested outside of the account at withdrawal for the specified match rates, marginal tax rates, interest rates, and years to withdrawal.

Tables

Table II: Descriptive Statistics by Match Rate

Match Rate	50	100	Match Rate	50	100
Count	3377	35954	Count	3377	35954
Panel A: Demographics			Panel B: Outcomes		
Percent Male	0.741	0.673	Percent Contributing	0.791	0.877
Percent Married	0.722	0.729	Mean Own Contribution	3467.09	4345.62
Percent with Pension Plan*	0.917	0.9002	Mean Own Contribution Percentage	0.0554	0.0634
Average Tenure*	12.09	15.17	Mean Conditional Own Contribution Percentage	0.0689	0.0719
Average Age	45.17	45.67	Percent Contributing to Company Stock	0.461	0.452
Median Income*	41608	60939			
Mean Marginal Tax Rate*	21.38	24.42	Percent who Contribute beyond Matching Cap	0.569	0.615
Full Sample of 39,331 observations			EBRI Data^		
Percent Male		0.678	Percent Male		0.524
Average Age		45.627	Average Age		39.5
Average Tenure		14.9	Average Tenure		6.7
Median Income		59580	Median Income		35136
Participation Rate		0.869	Participation Rate		0.849

All Statistics from 2003-2006 pooled sample.

* Demographic Characteristics are statistically different at a 95% level of confidence.

^ Source: EBRI Databook on Employee Benefits, Chapter 10, table 10.9 (2003) and BLS Occupational Employment Statistics (2005)

Tables

Table III: Summary Statistics on Marginal Tax Rates and Match Rates by State

State	Average Federal Marginal Tax Rate	Standard Deviation of Federal Rates	Average State Marginal Tax Rate	Standard Deviation of State Tax Rates	Both Match Rates Offered in State	> 5 % offered 50 % Match in State	Total Count
AR	19.43	5.33	7.12	0.16	Y	N	275
AZ	18.63	7.12	3.31	0.70	Y	Y	981
CA	20.51	6.32	6.79	2.79	Y	Y	866
CO	27.02	3.50	4.63	0.00	Y	Y	3
CT	20.06	6.11	4.34	0.88	Y	Y	204
DE	25.00	0.00	5.95	0.00	N	N	4
FL	19.87	6.01	0.00	0.00	Y	Y	311
GA	19.19	6.56	5.94	0.50	N	N	529
IA	20.20	5.74	6.72	0.60	N	N	1,568
IL	21.59	6.59	3.03	0.18	Y	Y	1,276
IN	20.16	5.75	3.41	0.13	Y	N	3,739
KS	20.06	9.02	5.72	1.63	N	N	424
KY	20.35	6.18	5.93	0.10	Y	Y	733
LA	17.60	5.78	4.23	0.77	N	N	508
MA	19.67	6.12	5.31	0.45	Y	Y	56
MD	20.81	5.34	8.22	0.60	Y	Y	16
MI	20.05	5.94	3.94	0.07	Y	N	3,526
MN	21.93	6.04	7.29	1.47	N	N	390
MO	22.12	5.72	5.56	0.52	N	N	130
MS	19.02	5.64	4.97	0.16	Y	Y	199
NC	19.50	5.47	7.08	0.25	Y	Y	312
NH	20.84	6.29	0.00	0.00	N	N	50
NJ	20.56	5.75	4.00	1.61	Y	N	445
NV	16.25	5.02	0.00	0.00	Y	Y	36
NY	21.14	6.15	6.79	0.87	Y	Y	1,642
OH	20.12	6.17	5.22	0.66	Y	Y	1,676
OR	25.00	0.00	9.00	0.00	N	N	8
PA	21.86	6.51	3.27	3.97	Y	N	5,930
RI	23.37	6.32	6.33	1.96	N	N	22
SC	19.38	5.69	6.95	0.44	N	N	1,214
SD	18.75	9.10	0.00	0.00	N	N	336
TN	21.90	5.94	0.00	0.00	Y	N	2,384
TX	19.00	6.52	0.00	0.00	Y	Y	4,954
UT	16.55	7.58	6.62	0.48	Y	N	357
VA	21.18	5.77	5.76	0.20	Y	N	3,032
VT	25.66	0.37	7.71	0.29	N	N	5
WA	21.16	5.99	0.00	0.00	Y	N	377
WI	19.58	6.32	7.65	1.32	Y	N	813

Source: Author's Calculations with assitance from the National Bureau of Economic Research Taxsim program (Version 8)

*The standard deviation of Pennsylvania's state tax rates is high relative to the mean state tax rate. This is largely due to the gradual tax forgiveness provisions present in that state. These provisions lead to very high estimated marginal tax rates for individuals on the "kink points" of the tax schedule. See 2006 form PA-40, page 35 for complete details.

Tables

Table IV: Baseline Specifications- Participation Rates

Column	I	II	III	IV	V	VI	VII
Method	OLS	OLS	OLS	OLS	IV	IV	IV
Count	39,331	39,331	39,331	39,331	39,331	39,331	39,331
Match Rate	0.00175**	0.000733**	...	...	...	0.000754**	0.000661**
	[0.000348]	[0.000286]				[0.000289]	[0.000287]
Marginal Tax Rate	...	...	0.00260**	0.00070	0.0143**	-0.00108	0.0118**
			[0.00051]	[0.00053]	[0.00174]	[0.00217]	[0.0017]
State Fixed Effects			X	X	X		X
Year Fixed Effects	X	X	X	X	X	X	X
Demographic Controls		X		X	X	X	X
Income, Age Controls		X		X	X	X	X
Instrument for Marginal Tax Rates					X	X	X

Coefficients represent the effect of a one-percentage point change in the indicated variable.
Standard Errors in Brackets. Standard Errors are calculated using clustering at the state level.
** Significantly different from zero at 5% confidence. * Different from zero at at 10% confidence.
All Specifications include Year Fixed Effects. Columns III-V and VII also include state fixed effects.
Columns I and II are estimated with match rates alone.
Columns III, IV, and V are estimated with marginal tax rates alone.
Columns V, VI and VII instrument for marginal tax rates with the simulated instrument value.
When indicated, demographic controls include: dummy variables for gender, marital status, ethnicity, defined benefit pension availability, and tenure; Income and Age controls include a five-knot cubic spline in income, and age decile fixed effects.

Tables

Table IV.2: Baseline Specifications- Participation Rates- Selected Covariates

Column (From Table IV)	VI	VI	VI	VI	VII	VII
Method	OLS	OLS	Probit	Probit	IV	IV
Count	39,331	39,331	39,331	39,331	39,331	39,331
Match Rate	0.000727**	0.000603**	0.000569**	0.000431**	0.00075**	0.000661**
	[0.000284]	[0.000258]	[0.000194]	[0.000155]	[0.000289]	[0.000287]
Marginal Tax Rate	0.00029	0.00072	0.00017	0.00053	-0.00108	0.0118**
	[0.000564]	[0.00053]	[0.000461]	[0.00042]	[0.00217]	[0.0017]
Age Decile 1	-0.014	-0.011	-0.015	-0.011	-0.014	-0.009
Age Decile 2	-0.033	-0.029**	-0.031**	-.027**	-0.033**	-0.025**
Age Decile 3	-0.040**	-0.036**	-0.039**	-.033**	-0.041**	-0.031**
Age Decile 4	-0.038**	-0.035**	-0.038**	-.034**	-0.038**	-0.032**
Age Decile 5	-0.051**	-0.048**	-0.053**	-.049**	-0.051**	-0.044**
Age Decile 6	-0.024	-0.021	-0.017	-0.015	-0.024	-0.015
Age Decile 7	-0.035**	-0.030	-0.034**	-.029*	-0.035**	-0.026
Age Decile 8	-0.049**	-0.044**	-0.052**	-.047**	-0.049**	-0.040**
Age Decile 9	-0.10**	-0.098**	0.115**	-.110**	-0.10**	-0.091**
Tenure 6-7y	0.057**	0.0951**	0.042**	0.0638**	0.058**	0.0928**
Tenure 8-10y	0.10**	0.108**	0.068**	0.0716**	0.102**	0.104**
Tenure 11-14y	0.12**	0.122**	0.076**	0.0816**	0.116**	0.118**
Tenure 15-17y	0.13**	0.128**	0.084**	0.0841**	0.125**	0.125**
Tenure 18-21y	0.14**	0.131**	0.089**	0.0862**	0.137**	0.128**
Tenure 22-25y	0.14**	0.136**	0.090**	0.0904**	0.138**	0.132**
Tenure 26-29y	0.14**	0.132**	0.092**	0.0863**	0.140**	0.129**
Tenure 30y+	0.09**	0.084**	0.09**	0.0604**	0.140**	0.079**
White	0.037**	0.0355**	0.034**	0.033**	0.038**	0.0338**
Married	0.12**	0.0125**	0.009*	0.0092**	0.002	0.090**
Male	0.352**	0.0362**	0.034**	0.0350**	0.036**	0.034**
Defined Benefit Plan FE	0.037	0.045*	0.036*	0.039**	0.035	0.044*
Year Fixed Effects	X	X	X	X	X	X
State Fixed Effects		X		X		X
Demographic Controls	X	X	X	X	X	X
Income, Age Controls	X	X	X	X	X	X
Instrument for Marginal Tax Rates					X	X

Coefficients represent the estimated effect of a one-percentage point change in the indicated variable.
Reported Probit coefficients are the estimated marginal effects.
Standard Errors in Brackets.
Standard Errors are calculated using clustering at the state level.
** Significantly different from zero at 5% confidence.
* Significantly different from zero at at 10% confidence.
All Specifications include Year Fixed Effects. State Fixed effects are included where specified.
Specification VII instruments for marginal tax rates with the simulated instrument value.
When indicated, demographic controls include: dummy variables for gender, marital status, ethnicity, defined benefit pension availability, and tenure; Income and Age controls include a five-knot cubic spline in income, and age decile fixed effects.

Tables

Table V: Baseline Specifications- Contribution Rates Conditional on Participation

Column	I	II	III	IV	V	VI	VII
Method	OLS	OLS	OLS	OLS	IV	IV	IV
Count	34,218	34,218	34,218	34,218	34,218	34,218	34,218
Match Rate	0.000072*	-0.000011	...	...	...	-0.00002	-0.000016
	[0.000041]	[0.000051]				[0.00006]	[0.000079]
Marginal Tax Rate	...	...	-0.0000145	0.00009	0.00154**	0.000686*	0.00159**
			[0.000093]	[0.000061]	[0.000167]	[0.000392]	[0.00022]
State Fixed Effects			X	X	X		X
Year Fixed Effects	X	X	X	X	X	X	X
Demographic Controls		X		X	X	X	X
Income, Age Controls		X		X	X	X	X
Instrument for Marginal Tax Rates					X	X	X

Coefficients represent the effect of a one-percentage point change in the indicated variable.
Standard Errors in Brackets. Standard Errors are calculated using clustering at the state level.
** Significantly different from zero at 5% confidence. * Different from zero at at 10% confidence.
All Specifications include Year Fixed Effects. Columns III-V and VII also include state fixed effects.
Columns I and II are estimated with match rates alone.
Columns III, IV, and V are estimated with marginal tax rates alone.
Columns V, VI and VII instrument for marginal tax rates with the simulated instrument value.
When indicated, demographic controls include: dummy variables for gender, marital status, ethnicity, defined benefit pension availability, and tenure; Income and Age controls include a five-knot cubic spline in income, and age decile fixed effects.

Tables

Table VI: Effect of a Ten Percentage Point Increase in the Match Rate on the Annualized 401(k) Spread

	τ=0.00; m=0.00				τ=0.15; m=0.00				τ=0.25; m=0.00		
	Rate of Return				Rate of Return				Rate of Return		
Age	0	0.03	0.07	Age	0	0.03	0.07	Age	0	0.03	0.07
25	0.249%	0.249%	0.249%	25	0.249%	0.250%	0.251%	25	0.249%	0.251%	0.253%
35	0.332%	0.332%	0.332%	35	0.332%	0.333%	0.335%	35	0.332%	0.334%	0.337%
45	0.498%	0.498%	0.498%	45	0.498%	0.500%	0.503%	45	0.498%	0.501%	0.506%
55	0.996%	0.996%	0.996%	55	0.996%	1.000%	1.005%	55	0.996%	1.003%	1.012%

	τ=0.00; m=0.50				τ=0.15; m=0.50				τ=0.25; m=0.5		
	Rate of Return				Rate of Return				Rate of Return		
Age	0	0.03	0.07	Age	0	0.03	0.07	Age	0	0.03	0.07
25	0.168%	0.168%	0.168%	25	0.168%	0.169%	0.169%	25	0.168%	0.169%	0.171%
35	0.225%	0.225%	0.225%	35	0.225%	0.226%	0.227%	35	0.225%	0.226%	0.228%
45	0.339%	0.339%	0.339%	45	0.339%	0.341%	0.342%	45	0.339%	0.342%	0.345%
55	0.692%	0.692%	0.692%	55	0.692%	0.695%	0.699%	55	0.692%	0.697%	0.704%

	τ=0.00; m=1.00				τ=0.15; m=1.00				τ=0.25; m=1.00		
	Rate of Return				Rate of Return				Rate of Return		
Age	0	0.03	0.07	Age	0	0.03	0.07	Age	0	0.03	0.07
25	0.127%	0.127%	0.127%	25	0.127%	0.127%	0.128%	25	0.127%	0.128%	0.129%
35	0.170%	0.170%	0.170%	35	0.170%	0.171%	0.172%	35	0.170%	0.171%	0.173%
45	0.258%	0.258%	0.258%	45	0.258%	0.259%	0.261%	45	0.258%	0.260%	0.262%
55	0.535%	0.535%	0.535%	55	0.535%	0.537%	0.540%	55	0.535%	0.539%	0.544%

0.01% = one basis point change in annualized rate of return.

Cells contain the difference in the ratio of the annualized internal rate of return between savings inside and outside of the 401(k) plan due to a 10 percentage point change in the match rate at the specified age, match rate, marginal tax rate, and annualized rate of return.

Simplifying Assumptions: Funds are withdrawn at age 65; No variation in marginal tax rates over time; Marginal Tax Rate at time of contribution equals marginal tax rate at time of withdrawl; novariation in rate of return over time.

Tables

Table VII: Effect of a Ten Percentage Point Increase in the Marginal Tax Rate on the Annualized 401(k) Spread

	τ=0.00; m=0.00				τ=0.15; m=0.00				τ=0.25; m=0.00		
	Rate of Return				Rate of Return				Rate of Return		
Age	0.00%	3.00%	7.00%	Age	0.00%	3.00%	7.00%	Age	0.00%	3.00%	7.00%
25	0.000%	0.291%	0.655%	25	0.000%	0.294%	0.668%	25	0.000%	0.296%	0.677%
35	0.000%	0.291%	0.655%	35	0.000%	0.294%	0.668%	35	0.000%	0.296%	0.677%
45	0.000%	0.291%	0.655%	45	0.000%	0.294%	0.668%	45	0.000%	0.296%	0.677%
55	0.000%	0.291%	0.655%	55	0.000%	0.294%	0.668%	55	0.000%	0.296%	0.677%
	τ=0.00; m=0.50				τ=0.15; m=0.50				τ=0.25; m=0.5		
	Rate of Return				Rate of Return				Rate of Return		
Age	0.00%	3.00%	7.00%	Age	0.00%	3.00%	7.00%	Age	0.00%	3.00%	7.00%
25	0.000%	0.294%	0.661%	25	0.000%	0.297%	0.674%	25	0.000%	0.299%	0.683%
35	0.000%	0.295%	0.664%	35	0.000%	0.298%	0.677%	35	0.000%	0.300%	0.686%
45	0.000%	0.297%	0.668%	45	0.000%	0.300%	0.681%	45	0.000%	0.302%	0.690%
55	0.000%	0.303%	0.682%	55	0.000%	0.306%	0.695%	55	0.000%	0.308%	0.705%
	τ=0.00; m=1.00				τ=0.15; m=1.00				τ=0.25; m=1.00		
	Rate of Return				Rate of Return				Rate of Return		
Age	0.00%	3.00%	7.00%	Age	0.00%	3.00%	7.00%	Age	0.00%	3.00%	7.00%
25	0.000%	0.296%	0.666%	25	0.000%	0.299%	0.679%	25	0.000%	0.301%	0.688%
35	0.000%	0.298%	0.670%	35	0.000%	0.301%	0.683%	35	0.000%	0.303%	0.692%
45	0.000%	0.302%	0.678%	45	0.000%	0.304%	0.691%	45	0.000%	0.306%	0.700%
55	0.000%	0.312%	0.702%	55	0.000%	0.315%	0.716%	55	0.000%	0.317%	0.725%

0.01% = one basis point change in annualized rate of return.

Cells contain the difference in the ratio of the annualized internal rate of return between savings inside and outside of the 401(k) plan due to a 10 percentage point change in the match rate at the specified age, match rate, marginal tax rate, and annualized rate of return.

Simplifying Assumptions: Funds are withdrawn at age 65; No variation in marginal tax rates over time; Marginal Tax Rate at time of contribution equals marginal tax rate at time of withdrawl; novariation in rate of return over time.

Tables

Table VIII: Calculated Effects on Wealth at Retirement for General Matching Scheme at m= 50%

		Parameters			
	Age	r=0.03 τ=0.15	r=0.07 τ=0.15	r=0.03 τ=0.25	r=0.07 τ=0.25
Panel I: Total Changes in Wealth	25	2.02	2.39	2.45	3.25
	35	1.96	2.21	2.33	2.84
	45	1.91	2.05	2.23	2.52
	55	1.86	1.92	2.14	2.26
Panel II: Baseline Changes Due to Tax Benefits	25	1.31	1.55	1.58	2.10
	35	1.27	1.43	1.51	1.84
	45	1.23	1.33	1.44	1.63
	55	1.23	1.33	1.44	1.63
Panel III: Incremental Changes due to Match Changes	25	0.71	0.84	0.86	1.14
	35	0.69	0.78	0.82	1.00
	45	0.67	0.72	0.79	0.89
	55	0.63	0.59	0.70	0.63
Panel IV: Incremental Changes Due to Effect of Match Changes on Contributions	25	0.06	0.07	0.07	0.09
	35	0.06	0.06	0.07	0.08
	45	0.06	0.06	0.06	0.07
	55	0.05	0.06	0.06	0.07

Source: Author's Calculations based on detail in the text.

Simplifying Assumptions: Tax Rates and Real Interest Rates are equal throughout lifecycle; Wages grow at the rate of inflation; Contribution Rate Conditional on Participation and Participation Rates prior to policy change are as in the dataset (7% and 87% respectively); effects of changes in match rate on contribution and participation rates are as estimated in Tables IV and V in Column II; Policy Change is permanent; Mean Annual Income is $60,000 and accounts are withdrawn at age 65.

Tables

Table IX: Calculated Effects on Wealth at Retirement for Increases in Tax Rates: $\Delta\tau=0.03$

Panel	Age	r=0.03 τ=0.15	r=0.07 τ=0.15	r=0.03 τ=0.25	r=0.07 τ=0.25
Panel I: Total Changes in Wealth	25	1.42	1.68	1.73	2.29
	35	1.38	1.55	1.65	2.00
	45	1.34	1.44	1.57	1.77
	55	1.31	1.35	1.51	1.59
Panel II: Baseline Changes Due to Tax Benefits	25	1.31	1.55	1.58	2.10
	35	1.27	1.43	1.51	1.84
	45	1.23	1.33	1.44	1.63
	55	1.20	1.24	1.39	1.46
Panel III: Incremental Changes due to Tax Changes	25	0.11	0.13	0.14	0.19
	35	0.11	0.12	0.14	0.17
	45	0.11	0.11	0.13	0.15
	55	0.10	0.11	0.12	0.13
Panel IV: Incremental Changes Due to Effect of Tax Changes on Contributions	25	0.07	0.08	0.08	0.11
	35	0.06	0.07	0.08	0.09
	45	0.06	0.07	0.07	0.08
	55	0.06	0.06	0.07	0.07

Source: Author's Calculations based on detail in the text.

Simplifying Assumptions: Tax Rates and Real Interest Rates are equal throughout lifecycle; Wages grow at the rate of inflation; Contribution Rate Conditional on Participation and Participation Rates prior to policy change are as in the dataset (7% and 87% respectively); effects of changes in match rate on contribution and participation rates are as estimated in Tables IV and V in Column V; Policy Change is permanent; Mean Annual Income is $60,000 and accounts are withdrawn at age 65.

Chapter 2

2 Portfolio Choice and Trading in 401(k) Plans: Do Allocative Constraints Bind?

2.1 Introduction

Household savings behavior is of particular interest to economists and policymakers. Existing literature on the savings behavior of households is substantial, and legislation that subsidizes targeted savings is commonplace. Perhaps the most widespread example of subsidized savings mechanisms are employer-sponsored 401(k) plans. These plans allow the employee to save a portion of their wages before they are subject to taxation (up to a nominal cap), as well as enjoy tax-free compounding of their savings until withdrawal at retirement. In exchange, the employee must leave the assets in the account until they reach a certain age or face back taxes and penalties.[19] In addition, employers often make saving in the company 401(k) plan even more attractive: employers often automatically enroll employees into the plan, allow for loans against the plan balance, and match employee's contributions to the plan at a fixed rate.

There is a substantial literature on how the form of savings incentives impact household participation and contribution rates in 401(k) plans. Milligan (2002), Klein (2009), and Cunningham and Engelhardt (2002) estimate the effectiveness of the tax incentives on participation and contribution rates, and Papke (1995), Papke and Poterba (1995), and

[19] Current law requires the employee be at least 59.5 years of age.

others, look at how changes in employer matching contributions can affect participation and contribution rates into these plans.

In terms of savings incentives and asset allocation, Bodie and Crane (1997) and Bergstresser and Poterba (2002) explain how households construct portfolios with varying tax burdens given differences in tax treatment between 401(k) accounts and ordinary savings; Choi, Laibson, and Madrian (2005) document an absence of employee contribution behavior, even when contributions are matched by the employer and the employee has no withdrawal restrictions. Agnew, Balduzzi, and Sunden (2003) detail how portfolios that employees hold in their 401(k) account look substantively different from their non-401(k) holdings in the overall riskiness, trading frequency[20], and equity exposure. Ameriks and Zeldes (2000); Bernartzi and Thaler (2001); and Liang and Weisbenner (2002) illustrate the prevalence of simplistic rules of thumb that seem to guide employee portfolio choice behavior in 401(k) plans. Choi, Laibson and Madrian (2004, 2008) show that the order of the portfolio decisions made by the household, or other seemingly benign aspects of plan design, can have significant effects on the allocation of assets within a 401(k) plan.

This paper focuses on employee asset allocation behavior in response to employer matching in Company common stock and trading restrictions on employer matching contributions. Matching employee retirement savings with company stock is common: Bernartzi (2001) and Poterba (2003) state that over one third of the total amount of assets in retirement plans of public companies are invested in company stock, though these numbers have decreased (slightly) since the publication date. Bernartzi, Thaler, Utkus, and Sunstein (2004), Poterba (2003), Muelbroek (2002), Ramaswamy (2003) and others illustrate how cash should be a preferred form of matching when compared to company stock for three key reasons: cash is flexible (employees can purchase company stock with cash), company stock contains a tremendous amount of idiosyncratic risk that can

[20] The available evidence suggests that outside of a tax-deferred account, investors trade much more frequently, often to their detriment. See Odean (1999).

be diversified away with the purchase of a related index, and the performance of company stock is highly correlated with an individual's labor income risk. This final point receives much attention whenever the economy declines: employees "over invested" in their company not only can find themselves out of a job, but also without their retirement savings if their employer fails.[21] Muelbroek (2002) and Ramaswamy (2003) calibrate a model and estimate that a dollar of matching contributions in company stock is worth roughly fifty cents to the employee once properly adjusted for risk. While the theoretical literature is quite clear, there is little empirical evidence to support the claim that employees manage their 401(k) portfolios with their exposure to company stock through matching contributions in mind. In fact, there is some evidence that matching in company stock rather than cash seems to increase the percentage of employee's discretionary contributions allocated towards company stock by roughly fifty percent.[22]

The goal of this paper is to exploit discontinuities in savings rules and incentives both over time and across employees to see if differences in plan design and portfolio constraints are associated with predictable changes in portfolio construction, either through rebalancing the entire portfolio, or through differences in the allocation of new contributions. In short, this paper addresses the question of whether or not portfolio constraints in 401(k) plans appear binding in equilibrium.

This paper is divided into five sections. The first section illustrates how matching in a particular asset and restrictions on trade can alter contribution and rebalancing behavior through a simplified portfolio choice problem. The second section describes the unique dataset and the identification strategy used in this paper. The third section describes the estimation equations used to identify the effect of trading constraints in the form of vesting restrictions and variation in match rates on employee rebalancing

[21] After the 2001 recession and the failures of firms like Enron and Lucent, whose employees were heavily invested in company stock, there was a dramatic increase in proposed legislation designed to limit company stock ownership in 401(k)s.

[22] Employee Benefit Research Institute Fact Sheet, 2002

behavior. The fourth section describes the estimation equations used to identify the effect of matching intensity on the composition of employee contributions. The fifth section concludes the paper and offers suggestions for future research.

2.2 The Model

I begin by extending the continuous time portfolio problem in Merton (1971) to include matching contributions in a particular asset. There are three assets: a risk-free asset (0), a risky asset (1), and company stock (2). Both risky assets have the same expected return, μ. Investors receive a stream of labor income I_t. Each investor chooses portfolio weights ϕ_{it} and consumption c_{it}. Instantaneous savings are matched in company stock at rate α. The risky assets have their own Brownian motion processes, Z_{it}.[23]

At every point in time, investors solve:

$$\max_{c_t,\phi_{it}} E[\int_t^T U(c_s)ds + U_T(c_T)]$$

With the evolution of wealth, W_t given by:

$$dW_t = dA_{0t} + dA_{1t} + dA_{2t} + dm_t + (I_t - c_t)$$

Where A_{it} is the amount already invested in each asset i, m_t is the existing value of the matching contributions, and $(I_t - c_t)$ is the instantaneous contributions to the plan. The evolution of A_{it} and m_t can be expressed as:

$$dA_{0t} = A_{0t}rdt = W_t\phi_{0t}rdt$$

$$dA_{it} = A_{it}\mu dt + A_{it}\sigma_i dZ_{it} = W_t\phi_{it}\mu dt + W_t\phi_{it}\sigma_i dZ_{it} \text{ for } i \in \{1,2\}$$

$$dm_t = m_t\mu dt + \alpha(I_t - c_t) + m_t\sigma_m dZ_{mt}$$

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[23] For simplicity, we'll assume that the two risky assets are uncorrelated. Relaxing this assumption leads to another term in the $dV(t, W_t)$ expansion.

Since the matching contributions are provided in terms of asset (2), we know that $dZ_{mt} = dZ_{2t}$ and $\sigma_m = \sigma_2$. Rewriting this system in terms of the Jacobi-Bellman Equation, we have:

$$V(t, W_t) = \max_{c_t, \phi_{it}}[U(c_t)dt + E(dV)] = 0$$

Rearranging terms and applying Ito's lemma, we know:

$$dV(t, W_t) = V_t + V_W[W_t r + W_t(\phi_{1t} + \phi_{2t})(\mu - r) + m_t\mu + (1 + \alpha)(I_t - c_t)] +$$

$$\frac{1}{2}V_{WW}[(W_t\phi_{1t}\sigma_1)^2 + (W_t\phi_{2t}\sigma_2)^2 + 2W_t\phi_{2t}\sigma_2{}^2 m_t + (m_t\sigma_m)^2]$$

The first order condition for consumption is given by:

1. $U'(c_t) = V_W(1 + \alpha)$

This is a standard envelope condition, modified by the matching "wedge" of $(1 + \alpha)$.

The first order condition for portfolio shares of the first asset is given by:

$V_W W_t(\mu - r) + V_{WW}\phi_{1t}(W_t\sigma_1)^2 = 0$, which implies

2. $\phi_{1t} = \frac{-V_W}{W_t V_{WW}}\frac{(\mu-r)}{\sigma_1{}^2}$

As $dZ_{mt} = dZ_{2t}$, the first order condition for investment in the second asset becomes:

$V_W W_t(\mu - r) + V_{WW}[\phi_{2t}(W_t\sigma_2)^2 + W_t m_t\sigma_2{}^2] = 0$, which implies

3. $\phi_{2t} = \frac{-V_W}{W_t V_{WW}}\frac{(\mu-r)}{\sigma_2{}^2} - \frac{m_t}{W_t}$

Note that equation (3) does not take the same form as equation (2). The presence of the matching contribution requires additional adjustment of the portfolio shares by the ratio of matched funds to total wealth. This result is intuitive: $\frac{m_t}{W_t}$ is the percentage of wealth in the portfolio from the matching contributions, so this condition requires that the total investment in the matched asset through incremental contributions and the existing portfolio share be equal to $\frac{-V_W}{W_t V_{WW}} \frac{(\mu - r)}{{\sigma_2}^2}$, as in equation (2).[24] There is another notable conclusion from equation (3): in the classical portfolio problem, preferences in the constant relative risk aversion family lead to constant portfolio shares over time. That is no longer the case – the optimal portfolio share in the asset that receives the matching contribution must be adjusted continuously according to the value of $\frac{m_t}{W_t}$.

2.3 Trading Patterns and Match Rate Variation

Insight on the magnitude of required trades is easiest with a simple example. Under constant relative risk aversion preferences, the value function is such that optimal portfolio shares satisfy:

$$\phi_{1t} = \frac{1}{\gamma} \frac{(\mu - r)}{{\sigma_1}^2}, \text{ and } \phi_{2t} = \frac{1}{\gamma} \frac{(\mu - r)}{{\sigma_2}^2} - \frac{m_t}{W_t}$$

Where γ is the coefficient of relative risk aversion. Since γ, μ, r, σ_1, and σ_2 are fixed, optimal shares vary over time only through variation in $(\frac{m_t}{W_t})$. Applying Ito's lemma to $(\frac{m_t}{W_t})$, and collecting terms involving α, we find:

$$d\left(\frac{m_t}{W_t}\right) = \alpha \frac{I_t - C_t}{W_t}\left(1 - \frac{m_t}{W_t}\right) dt + Adt + BdZ_{1t} + CdZ_{2t}$$

$$\frac{d\left(\frac{m_t}{W_t}\right)}{d\alpha} = \underbrace{\frac{I_t - C_t}{W_t}}_{>0} \underbrace{\left(1 - \frac{m_t}{W_t}\right)}_{>0} dt$$

[24] Note that a naive investor who does not combine dZ_{mt} and dZ_{2t} would set their portfolio shares continuously to equal: $\phi_{it} = \frac{-V_W}{W_t V_{WW}} \frac{(\mu - r)}{{\sigma_i}^2}$ and thus "over invest" in the second asset by the fraction $\frac{m_t}{W_t}$.

Where A, B, and C represent terms not involving α . Increasing the match rate increases the drift of the $\left(\frac{m_t}{W_t}\right)$ process, leading to larger changes in $\left(\frac{m_t}{W_t}\right)$ at each point in time, and larger trades to recover the optimal portfolio share of $\phi_{2t} = \frac{1}{\gamma}\frac{(\mu-r)}{\sigma_2{}^2} - \frac{m_t}{W_t}$.[25]

In the data, investors do not reallocate their portfolios continuously. In fact, amongst 401(k) investments, it is quite the opposite.[26] This behavior can be explained in part by transaction costs. In addition to brokerage fees and other monetary costs, 401(k) participants face a number of frictions that may limit their trading behavior. Employees must inform themselves as to the performance of the account, the current set of available assets, and the current rules that restrict trade and reallocation. Often, a 401(k) account is the only financial asset that the household owns. For such households, it may be the case that reallocating assets within the 401(k) portfolio also involves acquiring information on financial markets, securities, and risk. Such costs will lead to decreases in the frequency of trades across plan participants.

The presence of asset-specific matching contributions has two implications that are tested in this paper. First, fixed portfolio shares are not optimal: employees should frequently rebalance their portfolios, and this behavior should be driven by a desire to trade in the matched asset.[27] Second, employees with larger match rates should be less likely to invest in the matched asset.

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[25] This will remain true until there is no longer an interior solution for the investment in the matched asset. This may occur under a variety of circumstances, including: very high match rates; in cases where the matched asset is not mean-variance efficient (this is very likely in the case of Company Stock); or in cases where the matched asset covaries with I_t (this is also very likely in the case of Company Stock). At the boundary, the optimal ϕ_{2t} is zero.

[26] Madrian and Shea (2001); Choi, Laibson, Madrian, Metrick (2002, 2004); Agnew, Balduzzi, and Sunden (2003); Ameriks and Zeldes (2000); Mitchell, Mottole, Utkus, and Yamaguchi (2006); Liu and Loewenstien (2002).

[27] While the optimal portfolio vector, ϕ^* is a function of the match rate offered to the employee, we may expect to see employees that receive different match rates reallocate their 401(k) portfolio at a different rate as they have variation in the drift of their $\frac{m_t}{W_t}$ process.

2.4 The Data

The data comes from the human resources and benefits data from a large, US-based company ("Company" hereafter). The Company is a Fortune 500 enterprise in the manufacturing sector. The data includes information such as date of birth, tenure with the Company, wages, gender, and location of employment. Information on marital status and the number of dependents in the household is inferred from health insurance elections made by the employee. Finally, the data also includes information on the Company's 401(k) savings plan, including: the matching schedule available to each employee, data on the employee's own-money and total contributions to the plan, and the allocation of the employee's assets within the plan over time.

Each year, the Company distributes benefits information that includes a Summary Plan Description ("SPD") for the 401(k) plan. This SPD contains detailed information on the benefits of saving within the plan, including specific examples on the effect of tax deductibility of plan contributions on the employee's take home pay and savings, the associated pre-tax dollar limit for that year, and the relevant compensation limits from the Internal Revenue Service. Employees may enroll in the plan at any time by telephone or through the internet. Employees may then adjust, stop, or resume their pre-tax and after-tax contribution elections at any time via the phone or the internet.

The investment options are clearly detailed within the SPD, including descriptions of each fund, the appropriate ticker symbol, and the website for the fund. In 2007, there were eleven funds that employees could select as well as the Company's common stock, and a self-directed brokerage plan through a third party organization. The enrollment website also contains current and historical performance data for each available security. Dividends are automatically reinvested in their source fund. Employees may alter their contribution portfolio or their overall portfolio at any time, with the exception of matching funds, which may only be transferred after a vesting period of two years, or at any time if the employee is over the age of 55.

Importantly, while the match rate varies across employees, the difference in match rates is the only variation in plan details: there is no variation in the investment opportunities, matching caps, tax deductibility limits, or enrollment procedures across Company employees. The maximum contribution rate eligible for a match, the maximum amount of tax deductible contributions, the assets available, the form of the match (cash vs. Company stock), and the rules and restrictions governing loans and rebalancing are all identical across all of the employees. Indeed, the Company uses the same core summary plan description for all employees. Since match rates vary within the Company, the general SPD states that matching programs may be available to the employee, the maximum percentage of salary that the Company will match, the form of the matching (Company stock), and the vesting rules for the matching funds. The employee's local human resources representatives distribute a supplement to the SPD with detailed information on that particular employee's available match rate. The restricted dimensionality of plan benefits within the Company reduces potentially confounding effects of omitted variables and jointly varying plan benefits. Along with the detailed trading and contribution records, the similarity of plan details across employees is a key advantage of this data.

The sample of interest is all active, full time, hourly workers who participate in the employer-sponsored 401(k) plan. The data is restricted to hourly employees as their wages are very similar across the firm and the associated distribution of income is free from the pronounced skewness that is normally of concern when working with wage data. The sample is further restricted to include only states with more than one hundred employee-year observations. Table I contains summary statistics on the sample of interest.

There are fairly low rates of rebalancing by employees. Mean rebalance rates increase with age and tenure, though the relationship appears to be fairly flat over a large portion of the data, as shown in Figure 1. There appears to be a persistent difference in rebalance rates across match rates regardless of age or employee tenure.

2.5 Portfolio Constraints of Interest and Identification

There are two sources of identifying variation exploited in this paper: changes in the employee's status with respect to vesting restrictions, and differences in match rates across employees. The vesting constraints provide variation in how and how often employees are allowed to trade in the matched asset, and differences in match rates provide variation in the (lack of) diversification in the employee's 401(k) portfolios, and consequently the employee's desire to trade in the matched asset.

The first constraint of interest involves portfolio vesting and tenure requirements. Employees that receive matching contributions are unable to trade those contributions for a set period of time, though they are allowed to trade in their own-money contributions at any time. Once the required time period has elapsed, the funds become fully vested, and the employee is capable of trading the matching contributions. In particular, the Company requires that all employer matching contributions remain in Company stock for a period of two years, after which time the matching funds can be freely traded however the employee wishes. Importantly, the trading restriction only applies to the matching funds: the employee is fully capable of re-allocating their own-money portion of their 401(k) account at any time.

When an employee's tenure in the plan exceeds the two year vesting requirement, restrictions on their portfolio are relaxed and the employee is able to reallocate and diversify the matching funds. Variation in the ability to trade in particular assets will inform how much of an employee's desire to trade results from a need to alter their holdings in the matched asset. The removal of vesting constraints should lead to an increase in the propensity of employees to rebalance their portfolio, and an increase in the propensity to rebalance away from Company stock.

While vesting restrictions are binary in nature (the employee either is allowed to trade, or is not allowed to trade), the second constraint of interest in this paper deals with the intensity of portfolio restrictions and differences in the value of asset re-allocation across employees. In particular, the Company offers different matching rates across employees. In the Company, match rates vary on four dimensions: the city and state of the workplace, whether or not the employee is hourly or salaried, the employee's subsidiary company, and, amongst hourly employees, the employee's union status. Retirement benefits are selected by division heads within the firm. For example, two employees who work for the same subsidiary within the Company, but in neighboring cities, may receive two different match rates. That said, it is often the case that different subsidiaries are the result of historical acquisition behavior by the firm, so depending on the year of acquisition, much of the within-firm variation in match rates may be seen as variation across firms. There is no within-employee variation in the match rates over time, unless the employee changes their subsidiary, location of work, or union membership. While across-employee variation is free of concerns regarding inertia in portfolio choice behavior, it introduces other issues. The absence of within-employee variation in assigned match rates makes estimations with time-invariant fixed effects (ex: state controls) difficult to interpret as the residual identifying variation comes solely from newly hired and terminated employees, or employees who have otherwise became eligible for a different match rate, rather than the original match rate assignment by the respective division heads.[28]

[28] To this end, the preferred specifications involving match rates do not include state fixed effects, though their inclusion does not substantively alter the estimated coefficients.

Employees in the Company are offered matching contributions of 50% or 100% on the first 6% of wage income. Importantly, there are no employees with 0% match rates: all employees face plausibly binding portfolio allocation constraints in that they are "over invested" in Company stock.[29] Holding all other effects constant, employees with 100% matching contributions are required to hold a less diversified portfolio than employees with 50% matching contributions, though both groups of employees may be expected to exhibit trading behavior indicative of binding constraints for the reasons detailed at the outset of this paper.

2.6 Vesting Constraints and Rebalancing Behavior

This dataset contains detailed information on the savings behavior of plan participants. The contribution rate, individual securities purchased, rebalancing events, as well as the total balance and composition of the employee's 401(k) portfolio are included. The data provides detail on the composition of the employee's contributions and total retirement portfolio; when the employee rebalances their portfolio or alters their contribution mixture; which assets are traded conditional on any rebalance events; as well as the standard demographic information on an employee's age, gender, tenure, income, total 401(k) balance, and contribution rates. This level of detail allows for identification of the effects of portfolio constraints on the asset allocation behavior of employees.

The first question of interest is whether or not vesting constraints that restrict trade in the matched asset are binding. That is, is there evidence in the data that vesting restrictions alter trading frequency, flows of assets, or other retirement savings behavior in meaningful ways?

[29] Even employees with a 50% match rate who do not make any own money contributions to company stock hold $\frac{1}{3}$ of their portfolio in an individual security that is (1) highly correlated with their labor income and (2) has much more idiosyncratic variation than the market index (the volatility of daily returns of Company stock is 5.1 times as much as the S&P 500 over the same period).

I estimate the following specifications on the sample of all hourly employees with less than eight years of work experience with the Company:

4. $y_{it} = x_{it}\beta + z_{it}\Gamma + v_t + \varepsilon_{it}$

Where y_{it} is a dummy variable equal to one if the employee has rebalanced their retirement portfolio during the year[30]; x_{it} is a dummy variable indicating whether or not the employee has vested matching contributions; z_{it} is a vector of simple controls, including quadratic controls in age, linear controls in tenure and annual income; v_t are year fixed effects, and ε_{it} is a person specific error term. With this specification, an increase in the employee's propensity to rebalance their portfolio once they are allowed to trade out of Company stock will manifest as a positive point estimate for the β term.

Table II contains the results from the estimation detailed above. A Probit model is estimated, and marginal effects are reported. To allow for intra-group correlation, standard errors are clustered on the match rate offered to each employee. Note that with state and year fixed effects, the residual identifying variation comes from differences in the average tenure of employees across both states and years. As tenure is perfectly predictable on a sample of existing employees, the identifying variation with state and year fixed effects comes from changes in the sample of employees in each state over time through events like hiring, termination, and relocation. Similarly, the identifying variation with year fixed effects comes from changes in the national sample of employees through the same events.[31]

The point estimates in Table II suggest that employees recently passed the vesting period are roughly 3-7 percentage points more likely to rebalance their portfolios depending on the exact specification. Given that the mean rebalance rates and

[30] I estimate all specifications separately for 1) any rebalance event, and 2) only rebalance events that involve transferring funds out of company stock. Transactions involving company stock represent roughly 60% of all rebalancing events.

[31] I present the estimated effects with and without state and year controls. Though there is very little change in the resulting coefficients, and no statistical difference between the specifications, the specification without state fixed effects is preferred for reasons discussed above.

rebalance rates out of Company stock are 21.4% and 12.4% respectively, the point estimates in Table III suggest that the removal of a vesting constraint is associated with between one-eighth and one-third of all rebalance events. While the point estimates are comparable, the estimated coefficients for the effect of vesting on the employee's propensity to rebalance their 401(k) portfolio by trading *any* asset (in Columns I, III, and V) is only marginally significant. However, the estimated effects of vesting restrictions on *only* rebalance events including the restricted asset (in Columns II, IV, and VI) remains stable and statistically significant across all specifications and all sources of residual variation. The largest estimated effect on trades in the restricted asset comes from the specification without state and year fixed effects in Column II: the removal of vesting constraints is associated with a 5.52 percentage point increase in the propensity to rebalance the 401(k) portfolio through trades in the restricted asset (this is 44.5% of the mean rebalance frequency of 12.4%). The smallest effect comes from Column VI with both state and year controls: here, relaxing vesting constraints increases the propensity to rebalance the 401(k) portfolio by trading the restricted asset by 3.71 percentage points (29.9% of the mean rebalance frequency).

Increases in trading due to the removal of vesting constraints that restrict trade in the matched asset should impact employees with different match rates differently. I exploit this by incorporating information regarding the match rates offered to each employee. Higher match rates may lead to an increase in trading in general, while the interaction of the higher match rate and the removal of the vesting constraint are also of interest, as a higher match rate may heighten the desire to trade out of the matched asset and magnify the effects of the vesting constraint estimated in the previous section.

Table III contains estimates from the following specification:

5. $y_{it} = x_{it}\beta + z_{it}\Gamma + v_t + \varepsilon_{it}$

With y_{it} , v_t, and ε_{it} defined as before, and x_{it} as a vector consisting of: a dummy variable that is equal to one if the employee has any matching contributions eligible to trade, a dummy variable equal to one if the employee is offered a 100% match rate, and the interaction of these two effects. I also include specifications where the vector of controls, z_{it}, is expanded to include more flexible demographic controls, including: fixed effects for the employee's age and income deciles, as well as dummies for the employee's gender, marital status, and union status (coefficients omitted).

Results consistent with binding portfolio constraints through the match rate and vesting restrictions consist of positive point estimates for all of the x_{it}: employees are more likely to rebalance once the vesting constraints are lifted; employees are more likely to rebalance when their portfolios are more concentrated in Company stock as proxied by a higher match rate; and employees are more likely to rebalance when both of the above conditions hold.

The estimates for the effect of vesting on the propensity to rebalance remain stable across the specifications in Table II and Table III through the addition of the match rates and an increase in the flexibility of covariate controls. Employees are again 3 to 5 percentage points more likely to rebalance once they pass the vesting constraint (though the additional controls in Table III result in this effect losing significance at the 5% level). Participants are between 2 and 7 percentage points more likely to rebalance if they have a 100% match rate instead of a 50% match rate. The effect of vesting remains when rebalance activity involves trading in Company stock. Employees are roughly 4 percentage points more likely to rebalance out of Company stock (Column II and Column IV) if they both have passed the vesting cap and have a 100% match rate. Given the level of rebalancing activity, the point estimates in Table III suggest that variation in match rates and vesting restrictions can account for between one half and three-quarters of the mean rebalance frequency for employees who have passed the vesting constraint and who also have a 100% match rate. Employees are more likely to trade once their matching contributions have vested, and more likely still if they have a higher match rate. This effect remains similar in specifications that include time-invariant fixed effects (Column III and Column IV). In addition to the rebalance frequency, the detail in this data allows for inspection of the underlying asset flows during trades.

The second outcome of interest regarding the vesting constraint involves the asset flows of trades conditional on rebalance events. The data contains detailed information about the flow of funds in every employee's 401(k) account. For example, when an employee rebalances their portfolio, the data identifies the source and destination assets and the dollar amounts traded. This information can be used to see if vesting and match rate variation impact the cash flows of trades in addition to their effects on trading frequency.

Any such specification involves scaling the flows out of Company stock. I estimate two alternate specifications: first, the flows into or out of Company stock as a fraction of the employee's total 401(k) balance; and second, the flows into or out of Company stock scaled by the employee's annual income. The first approach has the appeal of being directly applicable to plan balances, but this measure is subject to quite a bit of noise as the value of the employee's Company stock holdings and the total account balance varies due to market movements in the asset values in addition to contribution and rebalancing behavior. Scaling by annual income avoids some of the volatility present when trades are scaled by total account balances, but is more difficult to map into trades as the employee contribution rate itself is endogenous.[32]

To be concrete, I estimate:

6. $y_{it} = x_{it}\beta + z_{it}\Gamma + v_t + \varepsilon_{it}$

With all variables defined as before, but with y_{it} defined as the dollar amount traded into or out of Company stock scaled by either the total amount of the employee's 401(k) balance, or the employee's annual wages. As the rebalance frequency is endogenous, I estimate these specifications both conditional and unconditional on rebalance events.

[32]Scaling by annual income also generates concerns about division bias: wages enter the estimation equation as both independent variables and in the denominator of the independent variable.

Specifically, I use three separate subsamples for employees with less than seven years of tenure with the firm: for all employees that participate in the 401(k) plan, whether or not they rebalance their portfolios during the year (7,822 observations); for only employees that participate in the 401(k) plan that also rebalance their portfolios during the year (1,644); and finally, for only employees that participate in the 401(k) plan that also rebalance their portfolio and whose rebalancing events involve trades in Company stock (951).

The removal of vesting constraints should lead to increased trade in Company stock. If the vesting constraint is binding, one might expect large flows out of Company stock once employees can diversify the matching contributions. This effect is likely to be amplified amongst employees who have a higher match rate and a less diverse 401(k) portfolio. That said, the results in Table III suggested that higher match rates are associated with more frequent rebalancing, so the impact of match rates on flows, conditional on a rebalance event, is ambiguous: employees with higher match rates appear to trade out of Company stock more often, so the amount taken out of Company stock during each trading event need not be larger for employees with higher match rates for them to transfer more out of Company stock in a given year.

Table IV contains the estimation results across three separate subsamples: all employee-year observations, only employees who rebalance during the year, and only employees who rebalance into or out of Company stock during the year.

There are several patterns in Table IV. In the first two columns, the estimation sample contains all employee-year observations and does not condition on any rebalance events. The point estimates in these columns suggest that the removal of the vesting constraint is associated with a decrease in the net flows into Company stock of two-thirds of one percent of the employee's total plan balance, and one half of one percent of employee annual income, though scaling by income results in point estimates that are not significantly different from zero. Employees with higher match rates withdraw still more funds from Company stock once they are vested and allowed to trade their matching contributions. These estimates suggest that an employee who just passed the vesting restriction with a 100% match rate on average pulls 1.5% of their total plan balance out of Company stock (or 0.8% of their annual income) each year, unconditional on any rebalance events. While the significance of the point estimate for the match rate varies across the first two columns, the combination of having a 100% match rate and being vested increases the amount that the employee is expected to pull out of Company stock each time they trade by 50% of the mean net flows out of Company stock when measured relative to annual income and by 100% of the flows when measured relative to total plan balance. Conditioning on rebalancing events (Column III and Column IV) leads to estimates that are larger in absolute value. Employees who pass the vesting restriction, have a 100% match rate, and rebalance their 401(k) portfolio transfer 5.52% of the total plan balance out of Company stock (53.5% of the mean flows), and they transfer 2.61% of their annual income out of Company stock (41.4% of the mean flows).

Removal of vesting constraints leads to more trading out of Company stock in every specification. Match rates appear to increase the amount traded out of Company stock, though this effect varies in sign and significance across the different samples and specifications. Again, this may be an artifact of the findings in Table III: higher match rates lead to more frequent rebalancing, so the asset flows conditional on rebalance events may well be lower for employees with higher match rates.

2.7 Match Rates and Contribution Composition

The previous section detailed the impact of vesting restrictions on the propensity of employees to rebalance their 401(k) portfolio, and the cash flows of the trades upon rebalance events. This section focuses on how larger flows of Company stock into the employee's 401(k) portfolio through variation in the match rate influences the employee's own-money asset allocation decisions.

First, I verify that the effects documented in the previous section do not vanish once the sample is extended to include employees of all tenure, and not simply those nearest to the vesting cutoff. Table V contains estimates of the effect of match rates and vesting restrictions on an employee's propensity to rebalance on the full sample of 30,091 employees. I estimate:

7. $y_{it} = x_{it}\beta + z_{it}\Gamma + v_t + \varepsilon_{it}$

With all of the variables defined as in equation (6), though with the sample of interest extended to include employees of all tenure.

The additional power from the increase in sample size yields significant coefficients on the effect of the vesting constraint, and the point estimates of the effect of vesting remain within one to two percentage points of those found in Table III. When an employee's matching contributions have vested, their rebalance propensity is increased by five percentage points, while the effect of being vested and having a 100% match rate increases the likelihood that the employee rebalances and rebalances involving Company stock by 13.4 and 10.4 percentage points respectively. In Table III, these values were 10.6 and 7.5 percentage points. Again, the coefficients in Table IV remain stable in the presence of state fixed effects, despite the time-invariant nature of the match rate in this sample. In the full data set, the possession of matching contributions that are vested is associated with more frequent rebalancing events, more frequent rebalancing events that involve trades out of Company stock, and this effect is intensified amongst employees with higher match rates.

Vesting constraints and match rate variation appear to impact the frequency of 401(k) portfolio rebalancing by employees, as well as trades executed conditional on rebalancing events. The next issue of interest is if employees modify the allocation of their contributions to account for the presence of higher match rates in Company stock. Employees with higher match rates should be less likely to invest their own money into Company stock as their portfolio is automatically more concentrated in that asset, and, if employees with a higher match have any own-money contributions in Company stock, they should be smaller than the own-money contributions of employees with a smaller match rate. The allocation of the contributions portfolio is measured three ways: first, a binary variable for whether or not the employee invests any of their own funds into Company stock above and beyond the employer's matching contribution; second, the actual dollar amount of the employee's total own-money contributions to Company stock; and third, the percentage of the employee's own-money contributions devoted to Company stock. Of course, employees who contribute their own funds to Company stock may react differently to grants of company stock than employees who do not purchase the asset.[33] Stratification on whether or not the employee makes any own-money contributions to company stock can highlight any differences in the effect of the match on employee's portfolios based on a revealed preference for Company stock. The dollar value and percentage measures of contributions are estimated on the full sample of all employees as well as on the strict subsample of employees who elect to invest their own money into Company stock. The estimation is done via Probit estimation for the binary measure, least squares for both the full and restricted sample and Tobit estimation for the full sample. I estimate:

8. $y_{it} = x_{it}\beta + z_{it}\Gamma + v_t + \varepsilon_{it}$

Where y_{it} is: a dummy variable equal to one if the employee purchases Company stock with their own funds, the amount of Company stock purchased with their own funds, and finally, the percentage of their own money contributions devoted to Company stock; x_{it} is a dummy for whether or not the employee is offered a 100% match rate; z_{it}

[33] Recall the calculations in Muelbrook (2002) that place the value of company stock at 40-60 cents on the dollar. Clearly, employees that purchase company stock with their own funds value the security at or above 100% of the asking price.

is a vector of age, wage, and tenure controls; and v_t are year fixed effects. Table VI contains the results of this estimation.

A higher match rate leads to a decrease in the likelihood of own-money contributions to Company stock by 19 percentage points (half of the mean rate of own-money contribution to Company stock). In addition to a decreased probability of contribution, a higher match rate leads to smaller contributions in Company stock amongst employees who have positive own-money contributions to Company stock. The significant negative effect of a higher match rate on own-money contributions to Company stock is present in every specification. The point estimates from the Tobit specification are particularly interesting (Column III): as in Table I, the mean level of annual contributions in the data is roughly $2,800. The average employee who receives a 100% match rate versus a 50% match rate has an additional $1400 in Company stock in their total annual contribution. The estimated decline in an employee's contributions to Company stock due to a 100% match rate versus a 50% match rate is $1,433, nearly identical to the additional amount of stock provided by the differences in the match rate. The ordinary least squares estimate (a $648 decline in own-money contributions) is smaller than the Tobit estimate, but still suggests asset substitution by employees at a rate of nearly 50%. This is especially surprisingly in light of the findings in Choi, Laibson, and Madrian (2008) that seem to suggest employees fail to take the form of the matching funds into account when allocating their own money contributions. These effects remain negative and significant when estimated as a percentage of total contributions as well. Employees with a 100% match rate automatically receive 17 percentage points more of their total contributions invested in Company stock.[34] This is very close to the Tobit estimates in Column VI which show an average 17.5 percentage point decline in the portfolio shares of own-money contributions to Company stock with an increase in the match rate from 50% to 100%. Increases in the match rate

[34] Employees with a 100% match rate, who contribute none of their own funds to company stock, still hold half of their portfolio in company stock, while employees with a 50% match have one third of their portfolio in common stock.

decrease both the likelihood that employees invest in the matched asset, and the amount that employees invest in the match asset.

Table VII contains the estimation equations from Table VI with the set of flexible covariate controls from the previous section.

The additional covariates lead to some attenuation of the coefficients, but the significant, negative effects of the match rate on own-money contributions in Company stock is still present in every specification. Employees are over thirteen percentage points less likely to invest in the matched asset with a match rate of 100% versus 50% (one third of the mean contribution frequency). In addition, the variation in the match leads to a decline in own money contributions to Company stock of $500 in the least squares specification and $900 in the Tobit specification, which ,with the mean annual contribution level of $2800, implies asset crowdout rates of 36% and 65% respectively. This effect remains when asset allocation outcomes are measured in portfolio shares rather than dollar amounts: the point estimates in Column V and Column VI suggest that employee's own-money share in Company stock decreases by between 13 and 23 percentage points as the match rate increases from 50% to 100%.

Variation in the match rate has a significant impact on the asset allocation of employee contributions. As the match rate increases, employees receive larger and larger fractions of their portfolio in Company stock. This is associated with a decreased likelihood that employees invest their own funds in Company stock, and, if they still invest in Company stock, they invest less on average than employees with lower match rates.

2.8 Conclusion

There are many different variables that impact the optimal portfolio for the household. This paper focused on the effects of vesting and portfolio allocation constraints on employee trading and contribution behavior in 401(k) plans. Through a uniquely detailed and comprehensive human resources dataset, this paper provides empirical estimates of the impact of vesting restrictions and matching contributions on the portfolio choice and rebalancing behavior of employees within 401(k) plans. The effects are pronounced: employees are 3 to 7 percentage points more likely to rebalance their portfolios once vesting constraints on the matched asset are removed, and this effect increases to 7 to 10 percentage points when the match rate increases from 50% to 100%. Together, these effects can account for up to half of the mean rebalance frequency.

In addition to portfolio rebalancing behavior, the composition of employee contributions changes with changes in match rates. Employees are 14 to 18 percentage points less likely to contribute any funds to Company stock if they have a 100% match rate compared to a 50% match rate (33-45% of the mean propensity to contribute to Company stock). If employees still contribute to Company stock with a higher match rate, they contribute less of their own funds, with asset crowd out at near one to one levels. These effects remain for different of measures of contribution behavior and across a variety of functional forms.

These results suggest that restrictions on portfolio choice and portfolio trading in 401(k) plans are binding in equilibrium. These point estimates may also inform future empirical research into the welfare costs of vesting restrictions and of matching in Company stock relative to cash that can enhance the existing theoretical literature on the welfare implications of asset-specific matching contributions.

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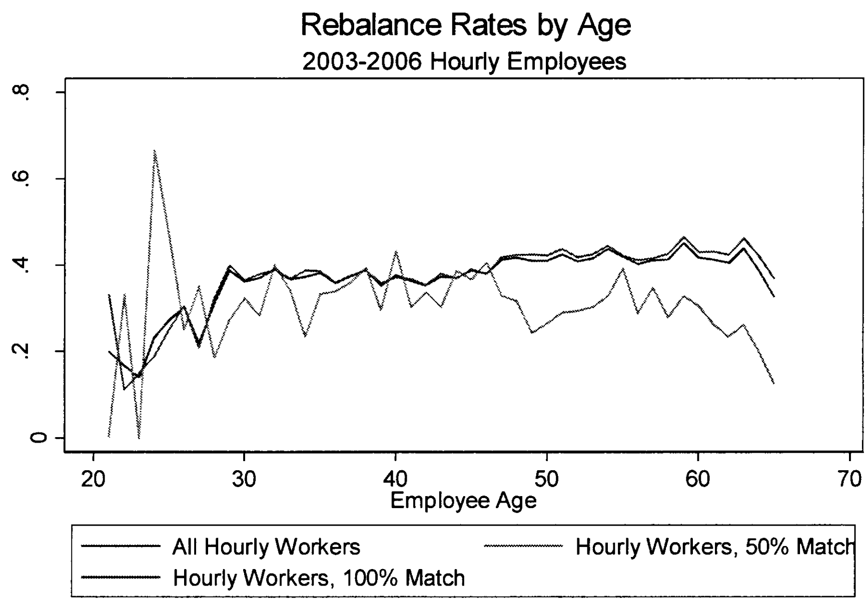
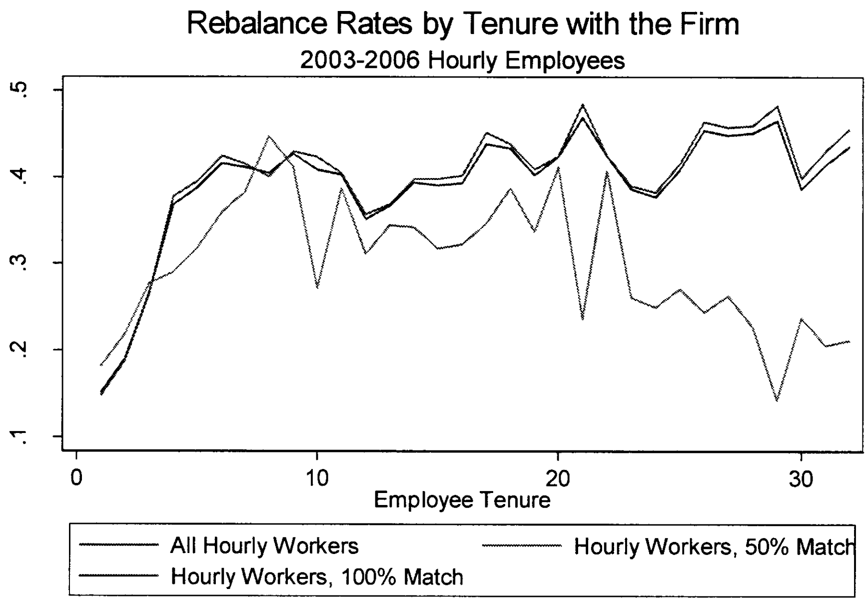
Figures

Figure 1



Figures

Figure 2



Tables

Table I: Summary Statistics

Sample	All Hourly Employees	Hourly Employees 50% Match	Hourly Employees 100% Match
Count	33,353	15,880	17,473
Demographics			
Percent Hourly	1.00	1.00	1.00
Percent with 100% Match	0.52	0.00	1.00
Percent Male	0.72	0.79	0.66
Percent Married*	0.74	0.82	0.66
Mean Age	46.26	47.70	44.95
Mean Tenure	16.36	18.18	14.70
Mean Annual Income	34,296	35,180	33,494
Median Annual Income	34,466	36,026	32,718
Outcomes			
Participation Rate	0.902	0.912	0.893
Dollar amount of Contributions	2,839	3,291	2,418
Contribution Rate	0.080	0.091	0.070
Percent who contribute own funds to Company Stock	0.368	0.456	0.287
Percent of Sample that Rebalances within the Year	0.244	0.219	0.264

All Employees come from the years 2003-2006 and face either a 50% or 100% match rate.
All Employees face the same matching cap (6% of annual income) and select investments from the the same menu of assets.
All outcomes except for the employee participation rate are conditional on participation.
There are 30,091 participating employee-year observations.

Tables

Table II: Propensity to Rebalance Around Vesting Discontinuity

Column	I	II	III	IV	V	VI
Dependent Variable	Any Rebalance Event	Rebalance Involving Company Stock	Any Rebalance Event	Rebalance Involving Company Stock	Any Rebalance Event	Rebalance Involving Company Stock
Count	7822	7822	7822	7822	7822	7822
Mean of Dependent Variable	0.214	0.124	0.214	0.124	0.214	0.124
Tenure Range (in Years)	0-7	0-7	0-7	0-7	0-7	0-7
<u>Coefficients</u>						
Dummy if Vested	0.0706**	0.0552**	0.0439	0.0418**	0.0323	0.0371**
	[0.0146]	[0.0071]	[0.0288]	[0.00216]	[0.0382]	[0.00292]
Age/10	-0.0159**	-0.0083**	-0.0155**	-0.00737*	-0.0151**	-0.00659
	[0.00233]	[0.0021]	[0.00107]	[0.00308]	[0.000027]	[0.00409]
Age Squared/100	0.0018**	0.00091**	0.00175**	0.000773	0.0017**	0.00071
	[0.00024]	[0.00027]	[0.000081]	[0.00040]	[0.00005]	[0.00049]
Tenure	0.0166**	0.0167**	0.00793	0.00853	0.00753	0.0077
	[0.00797]	[0.00647]	[0.00882]	[0.00789]	[0.0076]	[0.00698]
Wage/1000	0.0129**	0.00795**	0.0110**	0.00619**	0.0123**	0.0073**
	[0.00049]	[0.000438]	[0.00034]	[0.000062]	[0.000404]	[0.000071]
State Fixed Effects	N	N	N	N	Y	Y
Year Fixed Effects	N	N	Y	Y	Y	Y

Standard Errors in Brackets. Standard Errors are Clustered on Match Rates offered to Employees.
* = Significant at 10%, ** = Significant at 5%
All estimates are calculated via Probit methods. Marginal Effects Reported.
Columns I, II, and III estimate the propensity to rebalance the portfolio with any trades.
Columns II, IV, and VI estimate the propensity to rebalance the portfolio by trading into or out of Company Stock.
Columns I and II contain neither state nor year fixed effects.
Columns II and IV contain year fixed effects alone. This is the preferred specification.
Columns V and VI contain state and year fixed effects.

Tables

Table III: Propensity to Rebalance Around Vesting Discontinuity- Alternate Specifications

Column	I	II	III	IV
Dependent Variable	Any Rebalance Event	Rebalance Involving of Company Stock	Any Rebalance Event	Rebalance Involving of Company Stock
Count	7822	7822	7822	7822
Mean of Dependent Variable	0.214	0.124	0.214	0.124
Tenure Range (in Years)	0-7	0-7	0-7	0-7
Coefficients				
Dummy if Vested	0.046	0.0291	0.0435	0.0282
	[0.0332]	[0.02123]	[0.0286]	[0.0183]
100% Match Rate	0.0556**	0.00529*	0.0849**	0.0218**
	[0.0107]	[0.00317]	[0.00595]	[0.0094]
Vested * 100% Match	0.0042	0.0408**	0.00327	0.0405**
	[0.00728]	[0.00105]	[0.00436]	[0.00085]
State Fixed Effects	N	N	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Age Controls	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
Wage Controls	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects
Other Controls	Y	Y	Y	Y

Standard Errors in Brackets. Standard Errors are Clustered on Match Rates offered to Employees.
* = Significant at 10%, ** = Significant at 5%
All estimates are calculated via Probit estimation. Marginal Effects Reported.
Columns I and III estimate the propensity to rebalance the portfolio with any trades.
Columns II and IV estimate the propensity to rebalance the portfolio by trading into or out of Company Stock.
Columns I and II contain Year Fixed Effects alone. This is the preferred specification.
Columns III and IV contain State and Year Fixed Effects.

All Columns include flexible controls for demographics, including: age fixed effects, fixed effects for the decile of the wage distribution, as well as gender, marital status, tenure, and union status controls.

Tables

Table IV: Net Cash Flows into Company Stock

Column	I	II	III	IV	V	VI
Dependent Variable	Net Flows Into Company Stock / Total Plan Balance	Net Flows Into Company Stock/ Annual Wages	Net Flows Into Company Stock / Total Plan Balance	Net Flows Into Company Stock/ Annual Wages	Net Flows Into Company Stock / Total Plan Balance	Net Flows Into Company Stock/ Annual Wages
Eligible Transactions	All Employee-Year Observations	All Employee-Year Observations	Any Rebalance Event	Any Rebalance Event	Rebalance Events Involving Company Stock	Rebalance Events Involving Company Stock
Count	7822	7822	1644	1644	951	951
Mean of Dependent Variable	-0.0218	-0.0133	-0.103	-0.063	-0.223	-0.139
Tenure Range (in Years)	0-7	0-7	0-7	0-7	0-7	0-7
Coefficients						
Dummy if Vested	-0.00659**	-0.00572	-0.0472**	-0.0361**	-0.0689**	-0.1134**
	[0.00243]	[0.0041]	[0.00866]	[0.00412]	[0.0212]	[0.02116]
100% Match Rate	0.0025**	-0.00033	0.0458**	0.0256**	0.0517**	0.0112**
	[0.00111]	[0.00112]	[0.0037]	[0.0117]	[0.00925]	[0.00213]
Vested * 100% Match	-0.0111**	-0.0018**	-0.0538**	-0.0156**	-0.00511	0.0387**
	[0.000479]	[0.000547]	[0.00555]	[0.00802]	[0.00097]	[0.01779]
State Fixed Effects	N	N	N	N	N	N
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Age Controls	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
Wage Controls	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects
Other Controls	Y	Y	Y	Y	Y	Y

Standard Errors in Brackets. Standard Errors are Clustered on Match Rates offered to Employees.

* = Significant at 10%, ** = Significant at 5%

Columns I, III, and V estimate the net flows into Company Stock scaled by the employee's total plan balance.

Columns II, IV, and VI estimate the net flows into Company Stock scaled by the employee's annual income.

Columns I and II use the entire estimation sample of 7822 employees with less than 7 years with the firm, regardless of whether or not they have rebalanced their portfolio during the year.

Columns III and IV use an estimation sample of 1644 employees with less than 7 years with the firm who have also rebalanced their 401(k) portfolio at some point during the year.

Columns V and VI use an estimation sample of 951 employees with less than 7 years with the firm who have also rebalanced their 401(k) portfolio by trading into or out of Company Stock at some point during the year.

All Columns contain Year Fixed Effects alone.

All Columns include flexible controls for demographics, including: age fixed effects, fixed effects for the decile of the wage distribution, as well as gender, marital status, tenure, and union status controls.

Tables

Table V: Propensity to Rebalance, Vesting, and Match Rates: Full Sample

Column	I	II	III	IV
Dependent Variable	Any Rebalance Event	Rebalance Involving Company Stock	Any Rebalance Event	Rebalance Involving of Company Stock
Count	30091	30091	30091	30091
Mean of Dependent Variable	0.243	0.145	0.243	0.145
Tenure Range (in Years)	All	All	All	All
Coefficients				
Dummy if Vested	0.0634**	0.0510**	0.0629**	0.0484**
	[0.00527]	[0.0020]	[0.0197]	[0.0086]
100% Match Rate	0.05165**	-0.00357	0.0793**	0.0088
	[0.01891]	[0.00707]	[0.00955]	[0.0085]
Vested * 100% Match	0.0186**	0.05667**	0.0251**	0.0651**
	[0.00322]	[0.002386]	[0.0093]	[0.00523]
State Fixed Effects	N	N	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Age Controls	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
Wage Controls	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects
Other Controls	Y	Y	Y	Y

Standard Errors in Brackets. Standard Errors are Clustered on Match Rates offered to Employees.
* = Significant at 10%, ** = Significant at 5%
All estimates are calculated via Probit estimation. Marginal Effects Reported.
Columns I and III estimate the propensity to rebalance the portfolio with any trades.
Columns II and IV estimate the propensity to rebalance the portfolio by trading into or out of Company Stock.
Columns I and II contain Year Fixed Effects alone. This is the preferred specification.
Columns III and IV contain State and Year Fixed Effects.

All Columns include flexible controls for demographics, including: age fixed effects, fixed effects for the decile of the wage distribution, as well as gender, marital status, tenure, and union status controls.

Table VI: Propensity to Contribute Own Funds to Company Stock

Column	I	II	III	IV	V	VI	VII
Dependent Variable	Binary: Contributed Own Funds to Company Stock	Amount of Own Contributions to Company Stock	Amount of Own Contributions to Company Stock	Amount of Own Contributions to Company Stock	Percent of Own Contributions in Company Stock	Percent of Own Contributions in Company Stock	Percent of Own Contributions in Company Stock
Estimation Method	Probit - Marginal Effects Reported	OLS	Tobit	OLS	OLS	Tobit	OLS
Sample	Full Sample	Full Sample	Full Sample	Positive Own Money Contributions Only	Full Sample	Full Sample	Positive Own Money Contributions Only
Count	30091	30091	30091	12137	30091	30091	12137
Mean of Dependent Variable	0.403	595.85	595.85	1477.284	0.1884	0.1884	0.467
Tenure Range (in Years)	All	All	All	All	All	All	All
Coefficients							
100% Match Rate	-0.188**	-647.84**	-1433.06**	-923.15**	-0.3744**	-0.1754**	-0.225**
	[0.0154]	[62.435]	[35.837]	[100.56]	[0.00838]	[0.01266]	[0.0193]
Age/10	-0.0159**	-35.140**	-95.126**	-46.81**	-0.0272**	-0.01209**	-0.0113**
	[0.00242]	[7.076]	[13.807]	[14.61]	[0.00356]	[0.00261]	[0.000534]
Age Squared/100	0.00138**	3.869**	9.371**	6.487**	0.00249**	0.00116**	0.00125**
	[0.000221]	[0.8542]	[1.538]	[1.173]	[0.000408]	[0.000276]	[0.000058]
Tenure	-0.00242	11.427	7.036**	25.98**	-0.000030	0.00144	0.00445
	[0.0040]	[12.330]	[2.119]	[12.358]	[0.000560]	[0.00344]	[0.00355]
Wage/1000	0.0070**	23.227**	54.626**	42.722**	0.00872	0.00240**	-0.0013
	[0.0011]	[7.265]	[2.849]	[6.054]	[0.000789]	[0.000545]	[0.00186]
State Fixed Effects	N	N	N	N	N	N	N
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y

Standard Errors are Clustered on Match Rates offered to Employees. Standard Errors for Tobit Estimation are Bootstrapped with 200 repetitions.

* = Significant at 10%, ** = Significant at 5%

Column I estimates the effect of match rate variation on the propensity to contribute any funds to company stock via Probit estimation. Marginal Effects are Reported.

Columns II, III, and IV estimate the effect of match rate variation on the dollar amount of own-money contributions to Company Stock.

Columns V, VI, and VII estimate the effect of match rate variation on the percentage of own-money contributions invested in Company Stock.

Columns II, IV, V, and VII are estimated via ordinary least squares.

Columns III and VI are estimated via maximum likelihood Tobit models.

Columns IV and VII are estimated on the subsample of 12137 employee-years who have positive own-money contributions to Company Stock during the year.

All Columns contain Year Fixed Effects alone.

Table VII: Propensity to Contribute Own Funds to Company Stock- Alternate Specifications

Column	I	II	III	IV	V	VI	VII
Dependent Variable	Binary: Contributed Own Funds to Company Stock	Amount of Own Contributions to Company Stock	Amount of Own Contributions to Company Stock	Amount of Own Contributions to Company Stock	Percent of Own Contributions in Company Stock	Percent of Own Contributions in Company Stock	Percent of Own Contributions in Company Stock
Estimation Method	Probit - Marginal Effects Reported	OLS	Tobit	OLS	OLS	Tobit	OLS
Sample	Full Sample	Full Sample	Full Sample	Positive Own Money Contributions Only	Full Sample	Full Sample	Positive Own Money Contributions Only
Count	30091	30091	30091	12137	30091	30091	12137
Mean of Dependent Variable	0.4026	595.85	595.85	1477.28	0.1884	0.1884	0.467
Tenure Range (in Years)	All	All	All	All	All	All	All
Coefficients							
100% Match Rate	-0.135**	-498.34**	-884.139**	-740.05**	-0.133**	-0.231**	-0.182**
	[0.0329]	[146.91]	[50.442]	[181.897]	[0.0329]	[0.0119]	[0.0360]
Age Controls	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
Wage Controls	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects	Decile Fixed Effects
Other Controls	Y	Y	Y	Y	Y	Y	Y
State Fixed Effects	N	N	N	N	N	N	N
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y

Standard Errors are Clustered on Match Rates offered to Employees. Standard Errors for Tobit Estimation are Bootstrapped with 200 repetitions of sampling clustered on the match rate.

* = Significant at 10%, ** = Significant at 5%

Column I estimates the effect of match rate variation on the propensity to contribute any funds to company stock via Probit estimation. Marginal Effects are Reported.

Columns II, III, and IV estimate the effect of match rate variation on the dollar amount of own-money contributions to Company Stock.

Columns V, VI, and VII estimate the effect of match rate variation on the percentage of own-money contributions invested in Company Stock.

Columns II, IV, V, and VII are estimated via ordinary least squares.

Columns III and VI are estimated via maximum likelihood Tobit models.

Columns IV and VII are estimated on the subsample of 12137 employee-years who have positive own-money contributions to Company Stock during the year.

All Columns contain Year Fixed Effects alone.

All Columns include flexible controls for demographics, including: age fixed effects, fixed effects for the decile of the wage distribution, as well as gender, marital status, tenure, and union status controls.

Chapter 3

3 Precautionary Savings, Insurance Generosity, and Portfolio Choice

3.1 Introduction

Insurance is designed to decrease the magnitude of risks. There is a substantial literature in economics discussing how the presence of insurance can alter an individual's behavior towards insured risks. Often, this takes the form of moral hazard, as insured individuals face something less than the full marginal cost of their behavior with respect to the insured risk. This leads to inefficiency and represents a substantial cost to insuring individuals in the economy. However, if households self-insure against future risks through the accumulation of additional capital, then the provision of insurance can lead to more efficient outcomes. Such self insurance behavior is called precautionary savings. Precautionary savings is less efficient than an insurance scheme between households, in the sense that ex-ante expected consumption can be increased for all households with an insurance contract that allows for transfers across households in different states. That is, if households set aside some of their income each period for use in future states when the discounted marginal utility of consumption is higher than the present, and the amount of income set aside in this manner increases with the volatility of the future marginal utility of consumption, then insurance contracts lead to more efficient outcomes. This paper looks for evidence of precautionary savings behavior by exploiting variation in insurance benefits and analyzing the impact on asset accumulation and asset allocation decisions of households.

Addressing this question requires plausibly exogenous variation in insurance generosity across households, and the ability to accurately identify savings behavior over time. If such variation can be found, it is then possible to identify how in household savings changes with the generosity of insurance: increases in savings (or total asset holdings) that correspond to a decrease in insurance generosity is evidence of precautionary savings by households.

Exogenous variation in insurance generosity is difficult to find in data. However, the design of unemployment insurance in the United States is such that the generosity of the insurance (often measured by the replacement rate) varies across households depending on the state of residence, what the unemployment insurance benefits formulas were in that state in that particular year, and how much labor income the household received in the period immediately preceding unemployment. The variation in benefit rules across states and years provides a plausibly exogenous source of variation in insurance generosity. This paper utilizes the changes in unemployment insurance benefits across states at a point in time and within states over time to identify household precautionary savings behavior.

This paper makes four contributions to the existing literature on insurance and precautionary savings. The first relates to measuring insurance generosity. Insurance contracts can generally be characterized by incentives that operate on many different margins. For example, common insurance contracts consist of at least three components: deductibles that must be paid prior receipt of any payments, coinsurance rates that must be paid whilst receiving payments, and out of pocket maximums, beyond which no further payments are made. Increases or decreases in the generosity of insurance contracts can occur as changes in one or more of these components, and the relative effects of each component on savings behavior may not be equal. This is particularly relevant with unemployment insurance: benefits can be characterized by a payment that the unemployed individual receives each week, and the length of time payments can be collected. If households are concerned about long periods of unemployment, changes in initial insurance benefits (through the initial payment) may have different effects on savings behavior than changes in benefits for long unemployment spells (through the duration of payments). This extension yields estimates of savings behavior that suggest high levels of precautionary responses due to variation in unemployment insurance replacement rates and benefit durations, though these results are statistically insignificant.

The second contribution relates to econometric methods. Given the skewness of financial wealth, the effects of insurance benefits on savings behavior may be quite different across the quantiles of the wealth distribution. To that end, I estimate quantile specifications that allow insurance benefits to affect savings differently for households in different portions of the distribution of financial wealth. These methods suggest that savings crowd out responses are concentrated amongst households with below median levels of financial wealth, though this result is statistically indistinguishable from zero.

Third, households may have heterogeneous responses to the insured risk. As the risk of the insured loss varies across households, the precautionary savings response to variation in insurance benefits is likely to vary as well. I allow for insurance benefits to impact savings outcomes differently based the risk type of the household through a two-step estimation procedure. This process suggests that household savings behavior is more responsive to variation in insurance benefits as the likelihood of the insured risk increases (larger point estimates for higher risk households), though once this two-step procedure is bootstrapped for consistent standard errors, the results are insignificant at standard levels of confidence.

Finally, the composition of household precautionary capital is likely to be different from the composition of non-precautionary capital. That is, precautionary savings is likely to be held in very liquid, very safe accounts (like checking and money market accounts), as the capital may be required at any time, while non-precautionary savings are more likely to be held less liquid of more risky securities (like certificates of deposits or equity securities).[35] I allow the generosity of insurance to alter household asset accumulation differently across asset classes. This extension is unable to detect systematic differences in savings responses to unemployment insurance across asset classes.

This paper fits into the much broader literature on precautionary savings, such as calibrated modeling done by Hubbard, Skinner and Zeldes (1994, 1995) and Caballero (1991), where models that incorporate precautionary behavior better match the capital-income and age-consumption profiles in the economy. The most relevant literature is found in Gruber and Yelowitz (1999), and Engen and Gruber (2001). These papers identify precautionary savings behavior through variation in Medicaid and unemployment insurance benefits respectively. As identifying variation, unemployment insurance has some advantages over Medicaid. Specifically, the asset-tests present in Medicaid may lead to behavior that mimics precautionary savings (increasing benefits leads to a decrease in asset accumulation), but is driven by the household's desire to qualify for the insurance rather than to decrease precautionary capital at the margin. Indeed, recent quantile instrumental variables work done by Maynard and Qiu (2009) seem to support the hypothesis that savings responses due to Medicaid are largely because of asset tests rather than precautionary savings motives. For these reasons, this paper focuses on changes in unemployment insurance benefits as the source of variation behind precautionary savings behavior. This paper extends the literature in several ways: by including variation in unemployment insurance generosity above and beyond the replacement rate; by allowing different responses across households based on risk type; by searching for precautionary savings behavior in particular asset classes; and by more flexible estimation in terms of covariate controls and the functional form of the dependent variable.

[35] This is complicated somewhat by the access to credit that certain assets provide. For example, home equity can be drawn down to smooth consumption, though this is generally restricted when an individual is unemployed. As such, even though collateralizable assets have liquidity properties that are somewhat ambiguous, they are unlikely to represent precautionary savings for employment shocks.

This paper is also influenced by the literature on the benefits of unemployment insurance to households, whose modern research began with the consumption smoothing effects of the program in Gruber (1997), and the optimal level of social insurance in Chetty (2006). This has been recently extended in terms of the provision of liquidity to cash-constrained households in Chetty (2007, 2008), Chetty and Szedidl (2006) and the prevention of costly alternative consumption smoothing methods in Chetty and Looney (2005) and Cullen and Gruber (2000). In particular, the literature on the provision of liquidity motivates the distinction in this paper between savings in different asset classes to identify capital accumulation that is likely to represent precautionary savings (in very liquid, low risk accounts) from accumulation that is unlikely to represent this behavior.

This paper is divided into five sections. The first section provides background information on the institutional details of unemployment insurance in the United States. The second section discusses the dataset and identification strategy. The third section details the empirical results. The fourth section includes several specification checks and extensions, and the fifth section concludes the discussion.

3.2 Background on Unemployment Insurance

The ideal dataset for questions regarding precautionary savings and insurance would contain households that are offered varying degrees of insurance benefits against many different types of financial risks, such as health insurance, unemployment insurance, property insurance, and so on. The benefits to the household from the insurance should be substantial, as the larger the value of the insurance, the more likely variation in its benefits would lead to changes in household savings behavior. However, insurance policies are generally written to cover only one type of risk at a time, there is rarely plausibly exogenous variation across households in insurance coverage and generosity, and most insurance contracts cover relatively small risks relative to the present value of household assets. Unemployment insurance in the United States provides a setting where the variation in insurance generosity can be seen as exogenous (as the bulk of the variation in benefits is based on the state of residence), and the insured financial risk of unemployment is large relative to household income.[36]

There is substantial variation in the generosity of unemployment insurance benefits both within states over time and across states at a point in time. This variation occurs across multiple dimensions, including nominal weekly benefit amounts and the maximum duration that the individual can receive benefits. For example, in 2008, the maximum weekly benefit payable in the state of California was $450, while the maximum benefit to households in Arizona was only $250 (Department of Labor, 2008). Benefits are regularly extended during recessions: the maximum length of time that households can receive benefits varies between 26 and 39 weeks depending on the year of unemployment, the state of residence, and the replacement rate that the unemployed household receives. For example, a state may offer a household weekly benefit that represents a 50% replacement rate and a maximum duration of benefits of 26 weeks, but also restrict the total amount of benefits so that they do not exceed 25% of the individual's base period earnings. Such a restriction reduces the maximum benefit duration to 13 weeks.

The labor market risk facing households is substantial: according to the Bureau of Labor Statistics in early 2008, between 5% and 10% of labor force participants were unemployed and looking for work.[37] This percentage has nearly doubled in the last half of 2008 and early 2009. Upon unemployment, the financial loss to households is large. As the average duration of unemployment is between 16 and 18 weeks, households face

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[36] If there is systematic variation in risk preferences across states, this will confound direct estimation of the impact of unemployment insurance benefits on precautionary savings. This concern motivates the instrumental variables approach discussed in the next section.

[37] April 4, 2008 Employment Situation Summary, Bureau of Labor Statistics. The variation in this rate depends chiefly on how "labor force attachment" is defined. The BLS provides a variety of estimates.

a loss of income of $10,000 at the median levels of labor earnings in the estimation sample.

Unemployment insurance provides benefits that are designed to alleviate some of this loss. Depending on the labor earnings of the household, the state of residence, the year, and the duration of the unemployment spell, unemployment benefits can account for between 20% and 60% of lost labor earnings. Again, as benefit durations are often increased during recessions, the value to this program increases during periods where the household has a larger probability of unemployment and a longer expected unemployment duration.

There are some concerns with using variation in unemployment insurance benefits to identify precautionary savings behavior. Empirically, the savings rate in the United States is low. With low levels of household savings, it may be unrealistic to expect large amounts of precautionary capital, or the large variation in capital necessary to identify savings responses in the data. This concern is especially valid amongst households at high risk of unemployment, as they generally have lower annual incomes and lower accumulated wealth.[38] Second, foregone labor earnings are arguably a small part of the cost of unemployment. Frequently unemployed households are likely to experience human capital depreciation and lower future wages, neither of which is an insurable consequence of job loss. Households may engage in precautionary savings because of such concerns, though variation in unemployment insurance would not be expected to substantially alter the savings outcomes as these large risks are still present. Third, while the magnitude of lost earnings due to unemployment is large, the variation in replacement rates across states is usually on the order of 5-15 percentage points. It may be the case that this variation is simply too small to highlight precautionary savings effects. Fourth, the details of the unemployment insurance program are not well known

[38] However, Skinner (1988) estimates that up to 56 percent of total wealth accumulation can be explained through precautionary accumulation due to labor income uncertainty alone. The size of the precautionary motive in the context of unemployment may be sufficiently large to offset concerns about low savings.

to the public: individuals will not adjust their savings behavior with respect to changes in unemployment benefits if they do not know that any changes in unemployment benefits have taken place.[39]

3.3 The Data and Sample of Interest

This paper uses the 1990-1993, 1996, and 2001 panels from the Survey of Income and Program Participation (SIPP). [40] The SIPP (along with its topical modules) is designed to provide monthly information on the earnings, labor force participation rates, social program utilization and participation rates, demographics, finances, and taxation of households in the United States. Each panel varies slightly in the size of the cross section and the duration of the panel: the 1990 and 2001 panels contain three years of data, while the 1996 panel contains four years of observations. The number of households in each year varies: there are 1,760 households in the 2003 panel year, and 7,911 in the 1992 panel year. Importantly, the SIPP contains detailed information on household labor earnings, capital income, and asset holdings. Traditionally, the SIPP has oversampled low income and otherwise disadvantaged subsets of the population. While this may be of concern as these households are less likely to have significant asset holdings, these households are generally more likely to experience unemployment at any given point in time. There are a few other datasets that could be used to address this research question, but the SIPP has particular advantages. Compared to the Current Population Survey (CPS), the SIPP contains more detail on asset holdings and is focused on a population more likely to experience unemployment; compared to the Panel Study of Income Dynamics (PSID), the SIPP is a larger dataset with more detailed

[39] Information concerns are likely less of an issue amongst households very likely to become unemployed, or those who have a history of receipt of unemployment insurance benefits.

[40] The SIPP changed the structure of the survey substantially in 1996. As a specification check, I estimate certain regressions on the subsample of 1996 and 2001 surveys alone. These panels were selected over earlier panels because of their detailed responses regarding financial asset holdings.

information on financial holdings. In addition, the most comparable existing empirical work is estimated on the SIPP (Engen and Gruber (2001)).

The SIPP panels were subjected to a series of restrictions to ensure that the estimation sample was as relevant and reliable as possible. First, households that were not present for an entire calendar year during the panel were removed to remove noise from annual income and unemployment insurance benefit calculations. Second, households that were not employed at any point during entire year were dropped as their labor force attachment is low (thus the value of unemployment insurance is questionable), and unemployment benefits cannot be calculated without some measure of wages. Third, households whose head was not of working age (defined here as below 25 or above 64) were eliminated as they are not the main beneficiaries of unemployment insurance. Fourth, households with missing or imputed values, or otherwise unreliable entries for earnings or wealth during any month were dropped to ensure reliable savings and income data. Fifth, households must reside in a state that is uniquely identified within the SIPP: the SIPP state codes for some low population states are combined, and as such the unemployment insurance benefits cannot be calculated for households in these states.[41] The final sample contains annual observations from 58,921 households across ten different years over a 13 year time span. Table I contains summary statistics on the final sample.

There are a few statistics of note in Table I. The average unemployment rate for heads of households is over 10 percent. This is likely an artifact of the SIPP's oversampling of low income and disadvantaged populations mentioned above. The high rate of unemployment is one reason why the SIPP is especially attractive for identifying the effects of unemployment insurance. In addition, a large percentage of households have multiple sources of labor income. It is possible that unemployment spells are insured within the household by spousal (or other individual's) labor supply. This could

[41] This removes North and South Dakota, Maine, Vermont, Montana, Idaho, Alaska, Iowa and Wyoming from the analysis. The state of Michigan is removed as benefits in that state depend on marginal tax rates, and the low income sample in the SIPP makes such a calculation unreliable.

diminish the empirical effect of unemployment insurance on savings as the precautionary behavior takes place through employment rather than capital accumulation, though this concern is not unique to this sample. The wealth statistics also reflect the SIPP sampling procedures. Median wealth totals are low when scaled by annual income. Households seem to hold only about one to two weeks of labor income as savings at the median. It may be difficult to detect effects of unemployment insurance on savings with low levels of assets. Finally, the distribution of wealth is skewed and very disperse. This makes some sort of scaling for wealth holdings desirable, though the high variance in household wealth may be a factor limiting the statistical power that used to answer this question.

The objective of this paper is to quantify the effect of unemployment insurance benefits on precautionary savings. This requires defining a measure of savings behavior. The SIPP contains information on the size and allocation of the wealth of each household. The measure of interest is the total financial wealth of the household. "Financial Wealth" is defined as the total dollar amount accumulated in deposit banks, other financial institutions, and in stocks and bonds (both government and corporate). Note that this explicitly does not include home equity accumulation, as home equity growth can be interpreted somewhat differently than financial wealth accumulation, both in terms of empirical moments, and in terms of the impact on household behavior (Skinner (1989)). Financial wealth also does not include savings in individual retirement accounts or property that is not the principal residence of the household. These assets are extremely volatile and unlikely to represent precautionary capital: savings held in retirement accounts and investment property are not easily accessible and thus unlikely to represent self-insurance against unemployment spells.

There is substantial heterogeneity in asset holdings across households. In addition, financial wealth totals are quite skewed. Over 25% of the sample report holding no financial wealth whatsoever, and the 95th percentile belongs to households with nearly $80,000 in savings. The mean financial wealth holdings are roughly sixteen times the median level, and the distribution of financial wealth has a skewness statistic of +40. To make the empirical results more easily interpretable and comparable to existing estimates in the literature (Engen and Gruber (2001)), financial wealth holdings are scaled by annual income. However, I also estimate a variety of specifications with different measures of household savings, including specifications and methodologies more robust to highly skewed distributions.

I estimate regressions of the following form:

1. $y_{it} = x_{it}\beta + z_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it}$

Where y_{it} is the financial wealth of household i at time t scaled by their income; x_{it} are measures of unemployment insurance generosity; z_{it} is a vector of covariates and controls; α_i are state fixed effects; δ_t are year fixed effects; and ε_{it} is a household specific error term. To be clear, precautionary savings behavior is consistent with a decrease in scaled financial wealth holdings as unemployment insurance generosity increases, or in the context of the estimation equation above, a negative β coefficient.

3.4 Identification and Simulated Instruments

As discussed earlier, unemployment insurance is a particularly attractive area for study as the benefits change yearly and differ across states. That said, a simple regression of savings rates on unemployment insurance benefits has several issues. First, if households select where they live based in part on the generosity of government programs, such a specification will confound the effects of insurance benefits with the endogenous location selection embedded in household preferences. Second, differences in the distribution of incomes and unemployment probabilities across states and years may allow programs to be more or less generous in one area versus another. For these reasons, I implement a simulated instruments instrumental variables strategy as in Currie and Gruber (1996), Engen and Gruber (2001), and Chetty (2008).

The simulated instruments process has several steps. First, every head of household in a given year is run through the unemployment insurance laws in every state during that year. This program requires information on the individual's weekly wage, as well as the number of dependents in the household (as they impact benefit levels in some states). Information on the regulations used in calculation of unemployment insurance benefits across states and years is maintained by the United States Department of Labor.[42] The benefit calculator employed in this paper was first developed by Engen and Gruber (2001) and later extended by Chetty (2008). Second, the nominal weekly benefit amounts for each household in each state are turned into a replacement rate, the percentage of their weekly income when employed. Third, the average replacement rate from a national is sample is calculated in that state in that year. Finally, the average replacement rate is used as an instrument for the calculated replacement rates for all individuals that reside in that state in that year. This process is repeated for every year in the sample. The resulting instrument is purged of any state specific bias in preferences or initial distribution. Importantly, the differences in replacement rate for the simulated instrument are a result of changes in the regulations regarding unemployment insurance generosity across states alone.[43] I also estimated the baseline

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[42] For example, in the state of Florida in the year 2004, weekly benefit payments are determined according to a four step process. First, the workers baseline wage is calculated: in Florida, the baseline wage is the worker's earnings during the quarter in which earnings were highest over the preceding year. Second, the weekly benefit amount is calculated as a multiple of the baseline wage. In Florida, the benefits are calculated as 1/26th of the labor earnings during the highest quarter. Note that with 13 weeks in a quarter, this is designed to replicate a 50% replacement rate. Third, this dollar amount is compared to maximum and minimum benefit levels and adjusted if necessary. In Florida during 2004, these amounts are $32 and $275 respectively. Finally, this nominal benefit amount is divided by the worker's average earnings while employed to generate a replacement rate. Many states adjust this measure according to how many children live in the household, have different replacement rate objectives, and different maximum and minimum weekly benefit amounts.

[43] The same procedure is repeated to acquire a reliable instrument for the generosity of unemployment insurance as measured through the duration of benefits as well. Variation in maximum benefit durations comes from two sources. There can be hard coded maximum benefit durations that vary across states and over time, or the benefit duration can be changed due to soft caps that restrict the total amount of benefits payable to recipients.

specifications with a fixed national sample in a given year with no substantive change in the coefficients. I present only the variable year simulated instrument as this greatly increases the sample size (as the fixed sample allows the use of only one panel) and the variable year instrumental variables approach is comparable to existing work in Currie and Gruber (1996), and Engen and Gruber (2001).

The simulated instruments process purges the unemployment insurance benefits of state-varying endogeneity at the cost of household level variation. Remaining variation in the benefits measures varies only across states and years, rather than across each individual household at every point in time. In the presence of state and year fixed effects, the residual identifying variation in the benefits measures comes from the difference over time in the difference of the plan rules between states at a point in time. That is, a standard difference-in-difference type estimator. Table II contains summary statistics on the variation of the individual level replacement rate and benefit duration as well as the corresponding simulated instrument within and between individual states in the estimation sample of 58,915 household-years.

Mean simulated replacement rates vary from 33% in New Hampshire to 58% in Rhode Island. The twenty five percentage point difference represents 55.56% of the mean replacement rate of 45%. There is substantial variation within states over time as well. The within-state standard deviation of replacement rates is usually between 25-50% of the mean replacement rate. In terms of nominal weekly benefits, the state with the lowest average weekly benefit is Mississippi at $158, and the highest weekly benefit is in the state of Washington at $359; a $201 difference (86.2% of the mean weekly benefit of $233). Benefit durations have less variation both over time and in the cross section, as the standard deviation of benefit durations is between 15 and 25% of the mean maximum benefit duration for each state. The maximum difference in benefit durations across states is over one month: the most generous states have nearly 33 weeks of benefit availability, and the least generous states have 27 weeks of benefits.

The simulated instruments approach allows for straightforward identification of the effect of insurance generosity on household savings. Again, the estimation equations are of the following form:

2. $y_{it} = x_{1it}\beta_1 + x_{2it}\beta_2 + z_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it}$

Where $y_{it}, z_{it}, \alpha_i, \delta_t,$ and ε_{it} are defined as in equation (1), and the measure of insurance generosity (x_{1it} and x_{2it}) is the household's eligible replacement rate, maximum eligible duration of benefits, or both. I estimate several different regressions using different functional forms and controls in the z_{it}. These include: no covariate controls whatsoever; high order polynomials in earnings and the age of the household, as well as gender, marital status, educational attainment, race, and spousal labor supply fixed effects[44]; and finally, a specification where the polynomial controls in age and income are replaced with flexible cubic splines. Of course, as the covariate controls become more and more flexible, there is less and less residual identifying variation in the insurance benefits. In particular, the most flexible set of covariates and controls absorbs 70% of the total variation in insurance generosity.

First, I estimate a special case of equation (2) where the only measure of benefit generosity is the simulated replacement rate that the household can receive from unemployment insurance. Table III contains the coefficients from this estimation procedure. Table III includes all three specifications for z_{it}, as well as regressions estimated through ordinary least squares, a reduced form regression on the raw simulated instrument itself, and an instrumental variables approach estimated through two-stage least squares. Finally, a comparable point estimate from Engen and Gruber (2001) is included.[45]

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[44] By design, this specification is very similar to the one employed in Engen and Gruber (2001).
[45] For the purposes of comparison with the Engen and Gruber (2001) output, I estimate a specification without clustered standard errors in Column VI of Table III.

The point estimates from the instrumental variables specifications are all negative: increases in insurance generosity correspond to decreases in financial wealth accumulation, though none of the specifications meet the standard tests for statistical significance. The lack of precision could be due to a variety of factors, though the most likely is the high variation in household savings rates, as documented in Gruber (2000). The lack of statistical significance is despite point estimates that appear large in absolute value. In particular, the estimate from Column V of Table III suggests that decreasing unemployment insurance benefits by 10% (a 4.5 percentage point drop at the mean replacement rate of 45%) would lead to an increase in financial wealth to asset holdings of 0.026 (an increase of 4.8% at the mean financial wealth to asset ratios of 0.542). An increase in financial wealth holdings of 0.026 represents an increase in assets equal to an additional ten days of labor income. A 10% decrease in replacement rates causes an individual receiving the mean replacement rate that experiences an unemployment spell of six months to lose benefits equal to 2.25% of their annual income, or roughly eight days of labor earnings. That is, the point estimate suggests that changes in unemployment insurance benefits are completely offset by savings behavior. This effect is 16.4 times larger than the comparable coefficient from Engen and Gruber (2001), which is included in Column VII of Table III.[46]

Table IV contains the coefficients on selected covariates and controls from the specifications in Table III. Households seem to hold more financial wealth as they become older, when they are married, and they hold less wealth when they have more children.

There is more than one component to the generosity of insurance benefits. In particular, unemployed individuals receive a given replacement rate from for a given period of time. It may be the case that precautionary capital is accumulated to smooth

[46] This coefficient is taken directly from Engen and Gruber (2001). The coefficients from the comparable specification, when estimated on this data, are included in Column VI of Table III. When replicated on this sample, the resulting coefficient of -0.908 is 25 times larger (in absolute value) than the -0.0362 coefficient from Engen and Gruber (2001).

consumption over particularly long unemployment spells, rather than increasing consumption during relatively brief periods without labor income. To that end, I estimate equation (2), allowing the eligible benefit durations to impact savings behavior alongside the replacement rate.

Table V presents the results of ordinary least squares and instrumental variables regressions on replacement rates and benefit durations individually and simultaneously.

The instrumental variables specification yields negative point estimates for both of the measures of benefit generosity as in Table III. Once again, the household savings data appears too noisy for the estimates to be distinguishable zero at any reasonable level of confidence. In the joint instrumental variables specification with both benefit durations and replacement rates (Column VI), replacement rates have a similar effect as in the instrumental variables specification in Table III, which suggests an almost perfect offset to changes in unemployment insurance benefits through household savings. The point estimate on maximum benefit durations in Column VI of Table V suggests that removing one week of benefits leads households to increase their scaled financial wealth holdings by 0.0229, or an extra 1.19 week's worth of income in their wealth holdings. The coefficient on the replacement rate implied 100% crowd out of unemployment insurance benefits with savings, and the coefficient on benefit durations suggests nearly 120% crowd out. Despite these effects, neither point estimate is statistically distinguishable from zero. The lack of power in these hypothesis tests suggests that specifications more robust to volatile dependent variables may be required.

3.5 Alternative Dependent Variables and Quantile Estimation

Thus far, I have concentrated on savings responses as measured by changes in the total value of the household's financial asset holdings scaled by their annual income. This had several advantages. Scaling by annual income allowed for wealth accumulation to be interpreted through the number of weeks of labor income accumulated. This is a natural way to view the effects of replacement rates and benefits, as they are measured in weeks: coefficients imply a level of crowd out either based on an unemployment spell of a given length (for replacement rates) or directly (in the case of maximum benefit durations).

However, this measure of savings may be too volatile or too arbitrary to detect responses to insurance generosity. To this end, I also estimate the baseline specifications in equations (2) and (3) for a variety of different dependent variables, including: the natural log of financial wealth, the natural log of financial wealth scaled by income, and the raw level of financial wealth. The natural log specification has advantages and disadvantages. While logs are easily interpretable in terms of percentage changes in wealth, and the distribution of the natural log of wealth is much less skewed than the distribution of raw wealth, all of the households with zero reported wealth holdings are eliminated from the specification. In this sample, that removes 14,488 households (24.6%). The same sample loss is seen for log of financial wealth over income, though this specification retains the interpretation of savings in terms of weeks of income that allows for easy comparison to unemployment insurance benefits. Raw financial wealth totals are plausibly the most robust measure, as they are free from concerns regarding scaling and functional form. That said, wealth is extremely skewed, and estimates of mean effects are difficult to interpret across households. To accommodate these concerns, raw financial wealth specifications are estimated with quantile regression, an approach more suited to high levels of skewness and volatility as is present in financial wealth. For the quantile specifications, I estimate the effects of the simulated instrument directly on the 30th percentile, the median, and the 70th percentile of financial wealth.[47]

As before, I estimate:

3. $y_{it} = x_{1it}\beta_1 + x_{2it}\beta_2 + z_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it}$

With $x_{1it}\beta_1, x_{2it}\beta_2, z_{it}\gamma, \alpha_i, \delta_t,$ and ε_{it} defined as before, but with y_{it} representing log financial wealth, log financial wealth when scaled by annual income, and raw financial wealth depending on the specification. Table VI presents the effects of unemployment insurance benefits as measured by simulated replacement rates and benefit durations on savings for the alternate definitions of savings discussed above.

The alternative dependent variables do not provide statistically significant coefficients that are systematically different from the estimates in Table V. While replacement rates appear marginally significant in the natural log specification, this vanishes in the quantile regression. The bootstrapped standard errors in the quantile specification are such that the largest t-statistic in absolute value across all quantile specifications is 0.24. Changing the definition and functional form of savings parameterization of savings does not substantively change the significance of the effects of insurance generosity.

3.6 Incorporating Probability of Unemployment

Households are unlikely to change their savings behavior due to changes in unemployment insurance benefits if the households are unlikely to receive those benefits. Heterogeneity in the probability of unemployment across households may

[47] Given the pronounced skewness in financial wealth, I find a reduced form estimation is easier to interpret for quantile specifications than a quantile instrumental variables specification, while still maintaining the same identification assumptions.

lead to heterogeneity in the savings responses. Estimating a specification that can accommodate a differential response across households requires some way of identifying households that are at relatively high risk of becoming unemployed at every point in time.

The SIPP contains the three digit industry codes of the household's principal employer. There are roughly two hundred and fifty unique three digit industry codes present in the dataset. With the additional assumption that the industry the household is employed in impacts savings behavior only through the industry's effect on the household's probability of unemployment, this information can be used to distinguish between households based on probabilities of unemployment through a two-step estimation procedure. This estimation procedure will fail if systematic differences exist in benefits or in employee preferences across industries that lead to aggregate differences in savings behavior. In addition, this procedure requires that the industry of employment has a non-trivial impact on unemployment probabilities. This can be tested in the data. The average annual unemployment rate in the sample is 10.7%, while the unemployment rate across three digit industry code varies from 0.00% to 42.8%, with the 25th and 75th percentiles given by 6.5% and 16.67%, respectively.[48] The variation of unemployment rates across industries will be used to incorporate probability of unemployment into the savings specifications through a two-step procedure.

First, I estimate unemployment rates through the following equation:

4. $x_{3it} = \lambda_{it} + \overline{x_{1it}}\beta_1 + \overline{x_{2it}}\beta_2 + z_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it}$

Where x_{3it} is a dummy variable that indicates whether or not the head of household became unemployed during the year; λ_{it} are the set of fixed effects representing for the

[48] A regression of a dummy variable that indicates unemployment on industry fixed effects alone yields an F-statistic of 10.68, which with 241 restrictions on 58,915 observations is significant at more than the 0.0001 level of confidence.

industry where household i is employed in year t; z_{it}, α_i, δ_t, and ε_{it} are defined as in equation (1); and $\overline{x_{1it}}$ and $\overline{x_{2it}}$ are the simulated instruments for the replacement rate and maximum benefit duration offered by unemployment insurance. Given the predicted values of x_{3it} from equation (4), I transform the continuous measures of unemployment probability to a binary variable that is equal to one if the household's predicted probability of unemployment is greater than the median rate of unemployment in the sample. Given this measure of the likelihood of unemployment, I then estimate:

5. $y_{it} = x_{1it}\beta_1 + x_{2it}\beta_2 + x_{1it}\widetilde{x_{3it}}\beta_3 + x_{2it}\widetilde{x_{3it}}\beta_4 + \widetilde{x_{3it}}\beta_5 + z_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it}$

Where $\widetilde{x_{3it}}$ is the dummy variable that equals one if the household is at relatively high risk of unemployment during the year and all other variables are defined as in equation (1). This specification allows for the generosity of unemployment insurance as measured by replacement rates and benefit durations to impact household savings differently based on the household's relative risk of unemployment. As with any two-step procedure, the standard errors is the second stage have to be adjusted for the estimation in the first step. To this end, I bootstrap the entire two-step process with 100 repetitions. Table VII contains the estimated β coefficients from equation (5) that incorporate variation in unemployment probabilities. Precautionary savings effects are consistent with decreased wealth accumulation as replacement rates and benefit durations increase, especially amongst households that are more likely to become unemployed. In equation (5), this can be expressed as negative coefficients for $\beta_1 - \beta_4$.

Controlling for heterogeneity in unemployment probability decreases the magnitude of the point estimates for replacement rates, but the specification fails to yield point estimates that are statistically significant. The new estimates of changes in financial wealth due to variation in the replacement rate (Column II) suggest that households with relatively low probabilities adjust their savings due to variation in unemployment insurance benefits less than households with high probabilities. The specification including replacement rates, benefit durations, and unemployment probabilities (Column IV) yields point estimates on the replacement rate that are much smaller in magnitude, and households that are at high risk of unemployment adjust savings due to variation in the replacement rate nearly four times as much as low risk households. The signs of the coefficients on unemployment probability terms interacted with benefits are negative, but none of the estimated coefficients on replacement rates, maximum benefit durations, or the interactions with unemployment probabilities appear significant. Allowing household savings to respond to insurance benefits differently based on the likelihood of the insured risk is insufficient to detect any behavioral responses in this data.

3.7 Portfolio Choice

Capital dedicated to precautionary savings should be readily accessible at low cost. Wealth accumulated due to precautionary motives will likely be held in low risk, liquid assets. This suggests looking for differential effects on wealth accumulation across asset classes. Heterogeneous asset accumulation can also provide additional information on the costs of precautionary capital accumulation.[49] Importantly, if precautionary capital is concentrated in particular asset classes, households may engage in precautionary behavior without increasing their total financial wealth holdings. Instead, decreases in insurance benefits may lead to households holding more liquid and lower risk

[49] Liquidity is expensive: the difference in annualized rates of return between FDIC insured savings accounts and certificates of deposit or US Treasury bonds (all assets guaranteed by the Federal Government) is measured in hundreds of basis points. Not only is there the possibility of an over-accumulation of capital relative to a cross-household insurance scheme as in the typical precautionary savings framework, but each individual portfolio may be allocated inefficiently as it will contain too much liquidity and thus receive a lower annualized rate of return. It is important to note that this statement is true even holding risk constant (ex: an FDIC insured savings account versus an FDIC insured Certificate of Deposit), but changes in portfolio composition almost always imply changes in risk, so calculating welfare loss due to allocative inefficiency of portfolios is difficult. Such calculations are beyond the scope of this paper.

portfolios: a reallocation of financial wealth rather than an increase in its absolute level. This possibility requires distinguishing between different types of assets held by the household. The SIPP contains survey questions on the total amount and the concentration of the household's portfolio. I characterize assets as liquid or illiquid/otherwise non-precautionary according to the following matrix:

Asset Classification

Type of Asset	Financial	Non-Financial	Liquid	Illiquid /Non-Precautionary
Checking Account	X		X	
Savings Account	X		X	
Money Market Account	X		X	
Certificate of Deposit	X			X
Government Bond	X			X
Other Government Security	X			X
Corporate Bond	X			X
Equities	X			X
Retirement Account	X			X
Royalties		X		
Non-Residence Property		X		
Equity in Principle Residence		X		
Other Assets		X		

Many of illiquid/non-precautionary assets in the Asset Classification table can be transformed into cash. For example, equities, bonds, and certificates of deposit can be redeemed for cash with little notice. However, the volatility in equities makes them an unlikely vehicle for precautionary accumulation of capital, and transformation of certificates of deposit or retirement accounts into cash is associated with fees and penalties that often exceed ten percent of the amount invested in the asset. Such high volatility and costly penalties make these assets very unattractive for precautionary capital accumulation. I replace the general financial wealth measures of savings with measures of liquid and illiquid wealth as depicted in the Asset Classification table. Assets classified as financial enter into the financial wealth to income calculations, while non-financial assets do not. Assets classified as liquid financial assets enter into the liquid wealth over total income calculation, and non-precautionary assets are used to calculate the non-precautionary wealth to income ratio. Figure 1 presents the probability that the household owns any given asset across quantiles of the distribution of wealth, organized by liquid (Figure 1-A), illiquid and non-precautionary (Figure 1-B), and non-financial assets (Figure 1-C).

Recall from Table I that the median household's financial wealth holdings for this sample are $1,100, and median household annual income is $44,586. The median household accumulates enough savings to offset 1.28 weeks of unemployment. These 1.28 weeks of savings appear to be spread across multiple different types of assets. At the median financial wealth level of $1,100, households have between an 80% and 90% probability to hold checking or savings accounts, and a 70% probability to have retirement accounts of some form (through 401(k) accounts, Individual Retirement Accounts, or Keogh Accounts), and a 60% to 70% probability of having any equity in their primary residence. The probability of asset ownership rises essentially monotonically with wealth levels, and the median household appears to be quite likely to hold several different kinds of assets. At the 70th percentile of financial wealth ($5,500), the median household holds enough financial wealth to offset 6.41 weeks of unemployment, and this wealth appears to be spread across more asset classes than for the household at the 50th percentile. At the 70th percentile of financial wealth, households have greater than a ten percent chance of holding stocks, bonds, property, certificates of deposit, and money market accounts. There appear to be many households, even at low absolute wealth levels, that own a variety of different kinds of assets. The SIPP contains ownership information for twelve total asset classes.[50] In order to detect differences in portfolio construction due to variation in unemployment insurance benefits, it needs to be the case that a large fraction of households are making non-trivial portfolio allocation decisions among these different asset classes.

[50] These include: checking accounts, savings accounts, money market accounts, certificates of deposit, stocks, bonds, retirement accounts, investment property, equity in main residence, royalties, and other financial assets.

Figure 2 presents selected percentiles of the distribution of the number of different asset classes held by the household across the quantiles of the distribution of wealth.

The complexity of the household's portfolio as measured by the number of distinct asset classes within the portfolio increases monotonically with financial wealth levels. The median financial wealth household holds between two and three different asset classes on average, and the household at the 70th percentile of the financial wealth distribution holds between three and four assets, while the most diverse households have five different classes of the twelve total that are identified in the SIPP. Even the poorest households, with only $100 of assets, on average hold at least two different types of assets on average (most likely checking and savings accounts). It appears that households make substantive asset allocation decisions at many different wealth levels, and that the complexity of the asset allocation increases with financial wealth, despite the small amount of accumulated wealth relative to annual income.

Given the asset allocation decisions of households, it may be possible to detect precautionary savings behavior isolated amongst particular asset classes. This motivates replacing the dependent variable with liquid financial wealth to income and non-precautionary financial wealth to income as defined in the asset classification table, and looking for savings responses to replacement rates and benefit durations within these asset classes. I estimate:

6. $$y_{it} = x_{1it}\beta_1 + x_{2it}\beta_2 + x_{1it}\widetilde{x_{3it}}\beta_3 + x_{2it}\widetilde{x_{3it}}\beta_4 + \widetilde{x_{3it}}\beta_5 + z_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it}$$

Where $x_{1it}, x_{2it}, \widetilde{x_{3it}}, z_{it}, \alpha_i, \delta_t$, and ε_{it} are defined as in equation (5), and y_{it} is defined as the ratio of total financial wealth to income, liquid financial wealth to income, or non-precautionary wealth to income, depending on the specification. The results from this estimation procedure are shown in Table VIII. Every specification including $\widetilde{x_{3it}}$ is estimated according to the two-step procedure with the first step given by equation (4), and two-step standard errors are calculated via bootstrapping with 100 repetitions.

Again, there is not enough power to detect changes in savings behavior. The magnitude of the coefficients has decreased relative to the specifications in Table VII, and the point estimates in Table VIII are essentially indistinguishable from zero at any level of confidence. There are several possible explanations for the lack of power in this sample. The most likely is that household savings behavior is very volatile and there isn't enough power in the 58,915 observations to detect any changes in savings. Allowing household savings to respond to insurance benefits differently based on the liquidity and risk characteristics of assets was insufficient to detect any behavioral responses in this data.

3.8 Conclusion

This paper uses variation in unemployment insurance benefits to detect changes in the household's accumulation of precautionary capital. This paper augments previous research by extending the estimation sample to include more recent data from the Survey of Income and Program Participation, and then extending the model in several directions. First, the measures of insurance generosity are allowed to vary across multiple aspects of the unemployment insurance program. Previously, much of the attention was devoted to the effect of replacement rates, though unemployment insurance generosity varies in a number of ways. This paper extends the simulated instruments approach used to identify the effects of replacement rates to the maximum eligible duration for unemployment insurance benefits to see if different measures of benefit generosity impacted precautionary savings behavior in different ways. Second, quantile estimation methods and were included to accommodate the skewness in financial wealth accumulation and possible heterogeneous response to insurance benefits by households of different wealth levels. Third, this paper allows for heterogeneous responses by households based on the likelihood of the insured risk. The household's unemployment probability is instrumented with the industry of employment, and the relative risk of unemployment is allowed to impact household savings behavior. This two-step process allows households to respond to unemployment insurance benefits with different intensities based on their unemployment probabilities. Fourth, this paper allows precautionary capital to be accumulated in different asset classes based on the liquidity and risk characteristics of the assets. Though wealth holdings relative to annual income are small for the median household, there are non-trivial asset allocation decisions made by households in the data that support a precautionary/non-precautionary dichotomy based on the liquidity and risk characteristics of individual assets.

These procedures were unable to detect any significant evidence of precautionary savings behavior due to variation in unemployment insurance across households. There are a variety of possible explanations for this, ranging from the relatively small size of the unemployment insurance benefits themselves, to extreme variation in household savings, to the household's lack of knowledge of the variation in unemployment insurance benefits.

Future research in this area may want to utilize different types of insurance to identify changes in precautionary behavior. Variation in unemployment insurance benefits may not be large enough to generate detectable household savings responses. The challenge is to discover plausibly exogenous variation in insurance benefits across households outside of the realm of unemployment insurance, especially in a dataset that contains detailed asset accumulation and asset allocation information.

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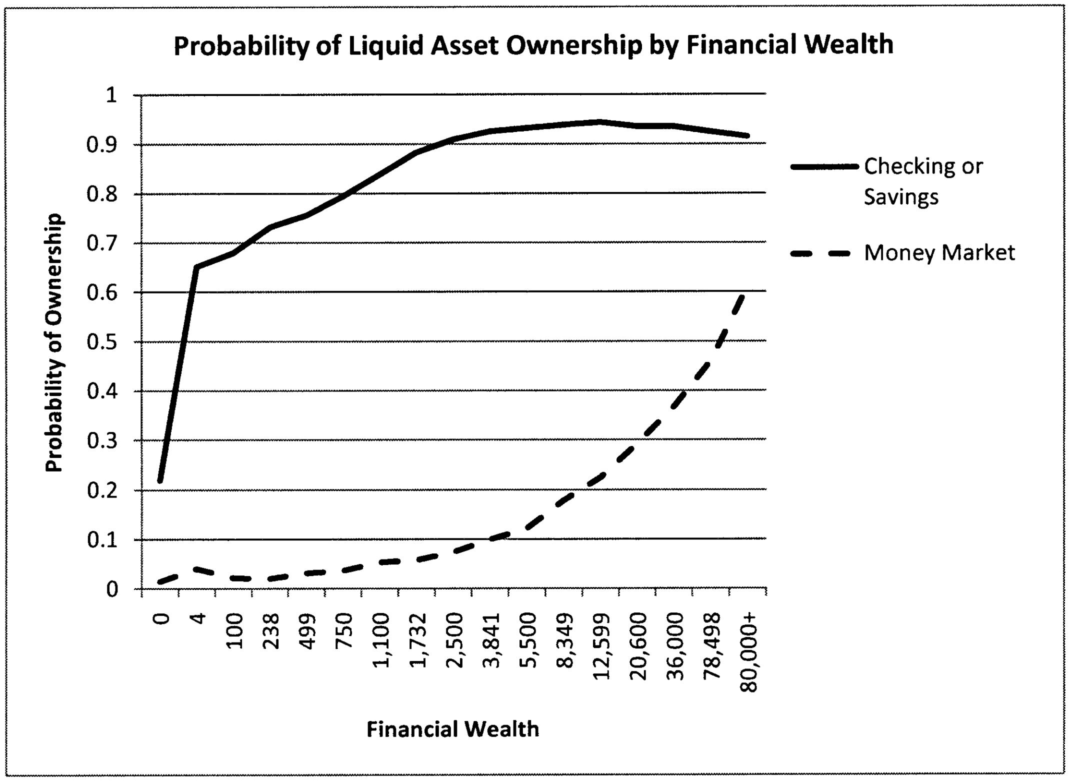
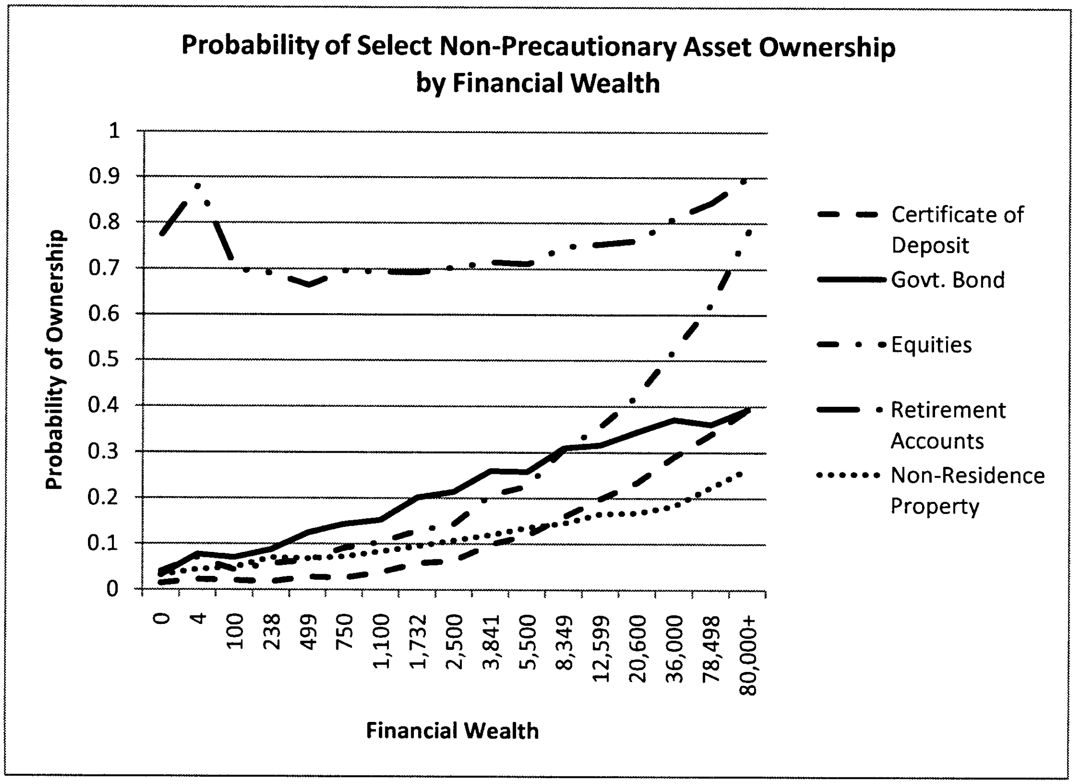
Figures

Figure 1-A



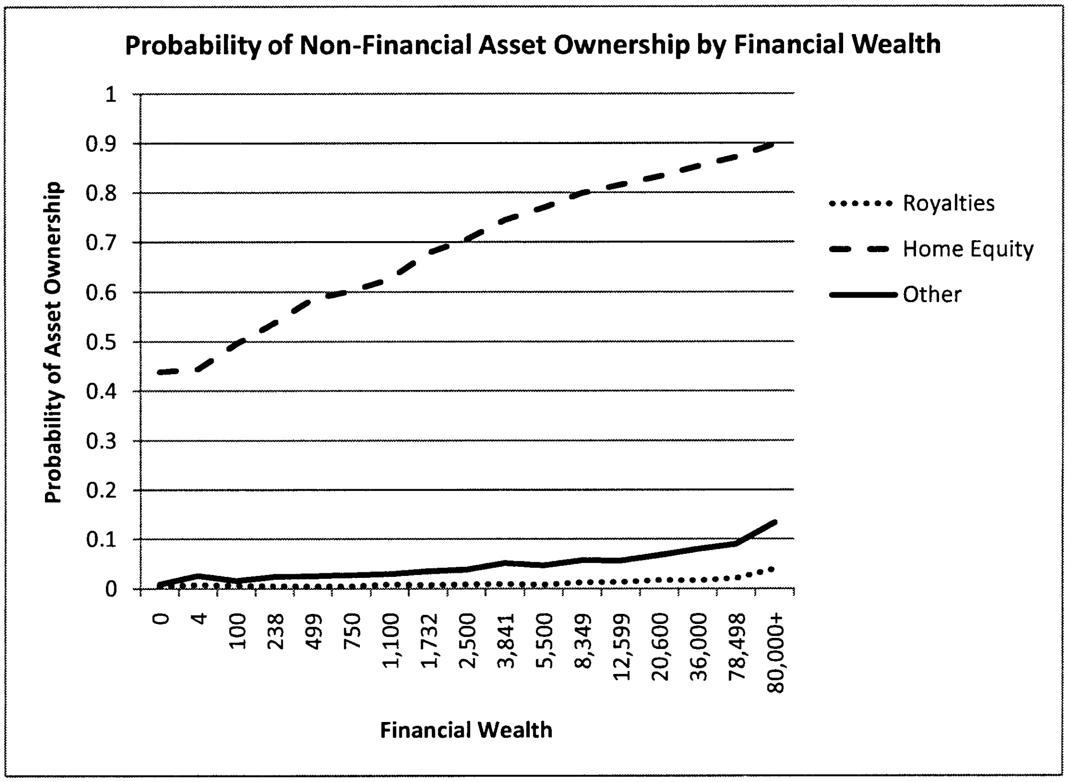
Figures

Figure 1-B



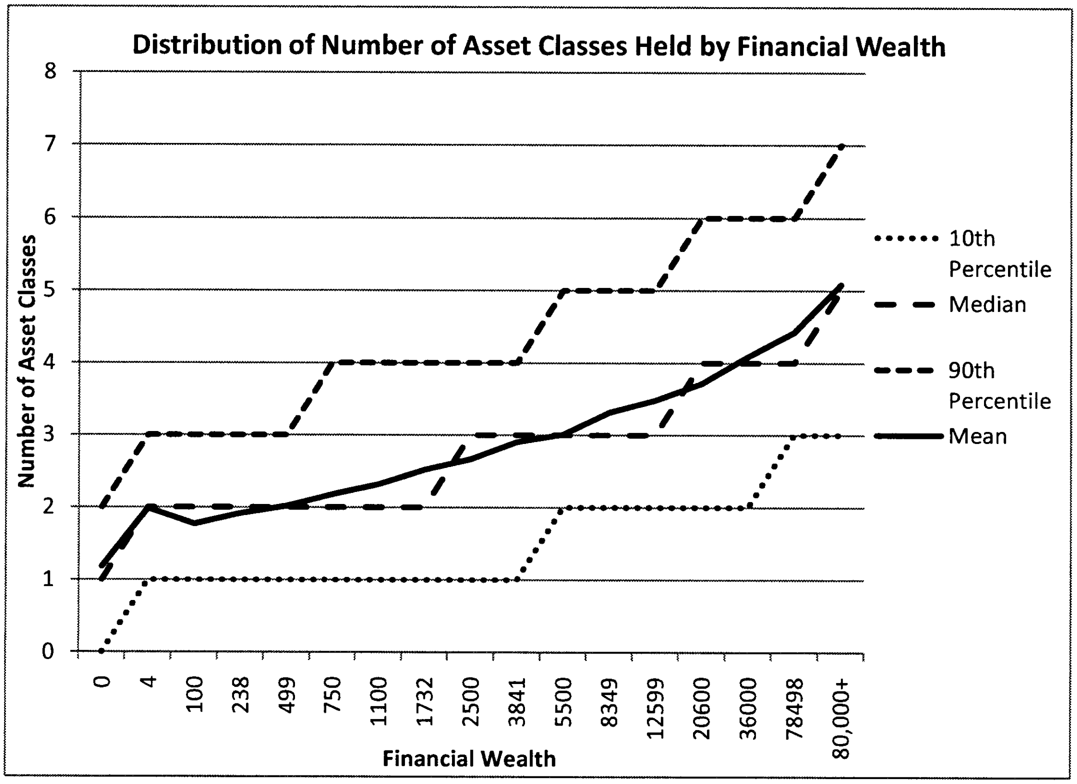
Figures

Figure 1-C



Figures

Figure 2



Tables

Table I: Summary Statistics on Sample of Interest

Panel I: Household Demographics	Full Sample	1991	1992	1993	1996	1997	1998	1999	2001	2002	2003
Number of Households	58,915	5,545	7,911	7,482	3,189	5,312	7,325	5,625	7,645	7,121	1,760
Percent Married	0.67	0.73	0.72	0.72	0.75	0.73	0.65	0.65	0.56	0.57	0.56
Percent with Male Head	0.67	0.78	0.76	0.76	0.67	0.66	0.62	0.62	0.58	0.57	0.56
Percent White	0.85	0.88	0.87	0.88	0.83	0.83	0.85	0.85	0.82	0.83	0.84
Percent with at least some College Education	0.58	0.55	0.56	0.57	0.55	0.56	0.61	0.61	0.59	0.60	0.61
Mean Number of Children in the Household	1.00	1.02	1.00	1.03	1.15	1.10	0.98	0.96	0.96	0.95	0.91
Percent of Married Households with Working Spouse	0.63	0.57	0.57	0.57	0.71	0.71	0.66	0.66	0.65	0.66	0.65
Mean Age of Head of Household	41.63	41.19	41.28	41.49	40.47	41.17	41.86	42.33	41.63	42.34	42.91
Percent of Households where Head Experiences Unemployment	0.11	0.10	0.10	0.09	0.14	0.12	0.10	0.09	0.14	0.12	0.13

Panel II: Income and Wealth	Full Sample	1991	1992	1993	1996	1997	1998	1999	2001	2002	2003
Median Income- Head of Household	28,050	26,448	26,680	27,185	25,252	25,685	28,848	29,889	29,611	30,763	31,694
Median Total Household Income	44,586	40,011	40,170	42,225	40,933	42,524	46,740	48,718	48,269	50,270	51,037
Median Financial Wealth	1,100	2,130	2,100	1,787	482	500	1,136	1,350	680	700	600
Mean Financial Wealth	17,841	16,652	17,806	18,571	14,707	15,925	18,627	26,005	16,818	1,487	17,170
Median Liquid Wealth	910	1,499	1,499	1,200	400	388	1,000	1,000	500	576	500
Mean Liquid Wealth	7,201	7,259	7,435	6,885	5,054	5,150	7,540	8,061	7,862	7,541	8,987

Summary Statistics are from 1990-1993, 1996, and 2001 panels of the Survey of Income and Program Participation.
Sample Selection criteria are detailed in the text.
Financial Wealth is defined as the sum of the household's asset holdings in checking accounts, assets held in banks and other financial instituitions, stocks, and corporate and government bonds.
Liquid Wealth is defined as the sum of the household's asset holdings in checking accounts and assets held in the bank.

Tables

Table II: Unemployment Insurance Generosity by State

State	Number of Observations	Mean Nominal Benefit	Standard Deviation of Nominal Benefit	Mean Replacement Rate	Standard Deviation of Replacement Rate	Mean Maximum Duration of Benefits	Standard Deviation of Maximum Duration of Benefits
Alabama	980	175.86	23.62	0.44	0.21	30.14	6.61
Arizona	1,443	177.40	35.06	0.40	0.18	29.61	5.84
Arkansas	537	217.04	78.02	0.50	0.16	28.65	5.07
California	7,425	202.32	63.96	0.38	0.16	31.80	6.41
Colorado	841	246.52	93.56	0.43	0.12	30.62	5.60
Connecticut	726	331.87	77.97	0.47	0.19	33.47	6.43
Delaware	191	272.13	53.59	0.48	0.21	32.80	6.33
District of Columbia	142	262.68	72.14	0.46	0.18	32.33	6.42
Florida	3,060	206.74	67.27	0.47	0.15	30.68	6.24
Georgia	1,819	226.42	45.66	0.44	0.21	26.76	7.22
Hawaii	139	290.01	86.68	0.54	0.19	33.20	6.49
Illinois	2,559	293.77	78.03	0.47	0.20	33.03	6.48
Indiana	1,523	193.79	68.21	0.41	0.20	29.75	7.11
Kansas	682	234.92	67.08	0.49	0.18	29.36	5.97
Kentucky	854	220.34	79.24	0.51	0.15	29.18	5.36
Louisiana	969	161.13	60.91	0.43	0.13	29.28	5.17
Maryland	1,013	236.60	43.00	0.39	0.19	32.61	6.50
Massachusetts	1,239	337.77	111.34	0.52	0.19	35.00	4.47
Minnesota	1,694	264.85	87.57	0.47	0.15	30.31	5.76
Mississippi	851	157.82	41.09	0.44	0.18	30.25	6.01
Missouri	1,530	187.20	44.31	0.42	0.19	30.06	6.13
Nebraska	714	173.14	59.01	0.39	0.17	30.33	5.93
Nevada	282	240.78	55.33	0.45	0.16	29.85	5.58
New Hampshire	403	175.18	47.38	0.33	0.17	31.48	6.43
New Jersey	1,917	309.61	107.66	0.51	0.18	30.88	6.30
New Mexico	251	196.14	56.80	0.46	0.18	30.55	6.18
New York	3,675	236.58	94.27	0.45	0.14	32.92	6.49
North Carolina	1,982	233.99	85.78	0.51	0.14	32.45	6.50
Ohio	2,532	219.45	70.23	0.44	0.13	32.17	6.49
Oklahoma	1,032	226.24	77.45	0.51	0.17	31.29	6.39
Oregon	928	269.55	88.71	0.53	0.16	29.10	5.11
Pennsylvania	2,938	292.66	96.02	0.53	0.16	31.93	6.48
Rhode Island	210	314.95	94.82	0.58	0.16	28.91	5.24
South Carolina	869	228.53	31.18	0.48	0.21	29.15	6.51
Tennessee	1,120	169.55	39.29	0.41	0.17	28.20	6.50
Texas	4,923	223.50	70.31	0.47	0.18	27.00	5.81
Utah	484	247.72	77.76	0.47	0.16	27.38	5.62
Virginia	1,372	232.60	45.68	0.41	0.22	27.48	7.40
Washington	1,064	358.58	101.10	0.53	0.20	30.11	6.08
West Virginia	556	200.71	89.50	0.51	0.09	32.29	6.50
Wisconsin	1,446	247.26	63.07	0.45	0.16	31.02	6.24

Benefits are calculated based on the Unemployment Insurance rules for a given state and year with the benefit calculator used in Chetty (2008).
Calculated nominal weekly benefits and replacement rates are not adjusted for eligibility criteria.

Tables

Table III: Effect of Variation in the Replacement Rate on Financial Wealth

Column	I	II	III	IV	V	VI	Engen & Gruber
Dependent Variable	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income
Sample Years	1990-2003	1990-2003	1990-2003	1990-2003	1990-2003	1990-2003	1984-1990
Method	OLS	OLS	RF	IV	IV	IV	IV
Replacement Rates	0.524**	1.425**	-1.03	-0.908	-0.591	-0.908	-0.0362**
	[0.145]	[0.366]	[0.719]	[0.625]	[0.555]	[0.725]	[0.0114]
Number of Observations	58,915	58,915	58,915	58,915	58,915	58,915	24,904
State and Year Fixed Effects	X	X	X	X	X	X	X
Demographic Controls		X	X	X	X	X	X
Spline Controls					X		
Clustered Standard Errors	X	X	X	X	X		

* = Significant at 10% level, ** = Significant at 5% level

The mean and median financial wealth to income ratios on the 1990-2003 sample are 0.539 and 0.0407, respectively.

Columns I and II use the individual-varying simulated replacement rate as the identifying variable.

Columns III-VI use the simulated instrument as the identifying variable: Column III is estimated through ordinary least squares on the instrument itself; Columns IV-VI are estimated through two stage least squares.

Column VI presents the coefficients from a similar specification as in Engen and Gruber (2001). Column IV contains the same specification, with standard errors clustered at the state level. The "Engen & Gruber" Column contains the comparable point estimate from their paper.

When indicated, demographic controls include a cubic polynomial in the age and earnings of the head of household, gender and marital status fixed effects, the number of children in the household, racial fixed effects, the level of education in the household, and a dummy variable indicating whether or not the spouse of the head of household was also employed. These controls absorb roughly 69 percent of the total variation in simulated replacement rates.

Spline controls replace the ordinary polynomials in age and income with flexible five and seven knot cubic splines respectively. Knots are placed for every ten years of age and twenty thousand dollars of earned income.

When indicated, standard errors are adjusted for clustering at the state level.

The F-statistic from the First Stage regression of the calculated replacement rate on the simulated instrument replacement rate is 2728.86.

Tables

Table IV: Selected Coefficients on Covariate Controls

Column (from Table III)	II	IV	V
	Financial	Financial	Financial
Dependent Variable	Wealth/Income	Wealth/Income	Wealth/Income
Sample Years	1990-2003	1990-2003	1996-2003
Method	OLS	IV	IV
Replacement Rates	1.425**	-0.908	-1.028
	[0.366]	[0.625]	[1.577]
Age	0.234**	0.230**	0.241
	[0.0924]	[0.089]	[0.152]
Wage	-0.000001	-0.000014**	-0.000014*
	[0.000002]	[0.0000035]	[0.000008]
Number of Children	-0.044**	-0.035**	-0.030**
	[0.0080]	[0.0085]	[0.0119]
Married Fixed Effect	0.322**	0.319**	0.338**
	[0.544]	[0.0528]	[0.0586]
Spouse Employment Fixed Effect	0.0059	0.0033	-0.0129
	[0.0337]	[0.0325]	[0.0421]
Male Fixed Effect	0.136**	0.173**	0.151**
	[0.0504]	[0.0528]	[0.0616]
Number of Observations	58,915	58,915	37,977
State and Year Fixed Effects	X	X	X
Demographic Controls	X	X	X
Clustered Standard Errors	X	X	X

* = Significant at 10% level, ** = Significant at 5% level

The mean and median financial wealth to income ratios on the 1990-2003 sample are 0.539 and 0.0407, respectively.

Column II uses the individual-varying simulated replacement rate as the identifying variable. Columns IV and V use the simulated instrument as the identifying variable.

When indicated, demographic controls include a cubic polynomial in the age and earnings of the head of household, gender and marital status fixed effects, the number of children in the household, racial fixed effects, the level of education in the household, and a dummy variable indicating whether or not the spouse of the head of household was also employed. These controls absorb roughly 69 percent of the total variation in simulated replacement rates.

Tables

Table V: Incorporating Maximum Benefit Durations

Column	I	II	III	IV	V	VI
Dependent Variable	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income
Method	OLS	IV	OLS	IV	OLS	IV
Replacement Rates	0.0744	-0.591	...	...	0.126	-0.526
	[0.444]	[0.555]			[0.496]	[0.563]
Maximum Benefit Duration	...	...	0.0023	-0.0228	0.003	-0.0229
			[0.0050]	[0.0153]	[0.006]	[0.0151]
Number of Observations	58,915	58,915	58,915	58,915	58,915	58,915
State and Year Fixed Effects	X	X	X	X	X	X
Demographic Controls	X	X	X	X	X	X
Spline Controls	X	X	X	X	X	X
Clustered Standard Errors	X	X	X	X	X	X

* = Significant at 10% level, ** = Significant at 5% level

The mean and median financial wealth to income ratios on the 1990-2003 sample are 0.539 and 0.0407, respectively.

Columns I, III, and V use the individual-varying simulated replacement rate as the identifying variable.

Columns II, IV, and VI use the simulated instrument as the identifying variable and are estimated through two-stage least squares

When indicated, demographic controls include a cubic polynomial in the age and earnings of the head of household, gender and marital status fixed effects, the number of children in the household, racial fixed effects, the level of education in the household, and a dummy variable indicating whether or not the spouse of the head of household was also employed. These controls absorb roughly 69% of the total variation in simulated replacement rates and 75% of the variation in benefit durations.

Spline controls replace the ordinary polynomials in age and income with flexible five and seven knot cubic splines respectively. Knots are placed for every ten years of age and twenty thousand dollars of earned income.

When indicated, standard errors are adjusted for clustering at the state level.

Tables

Table VI: Alternate Dependent Variable Transformations

Column	I	II	III	IV	V	VI
Dependent Variable	Financial Wealth/Income	Log (Financial-Wealth)	Log (Financial-Wealth / Income)	Financial Wealth	Financial Wealth	Financial Wealth
Method	IV	IV	IV	Quantile Reduced Form	Quantile Reduced Form	Quantile Reduced Form
Percentile	...	...	...	30th	50th	70th
Replacement Rates	-0.526	-0.681*	-0.689	-279.36	-722.74	20037.61
	[0.563]	[0.413]	[0.421]	[1831.63]	[47110.2]	[106827.3]
Maximum Benefit Durations	-0.023	-0.003	-0.0029	3.694	3.637	-83.27
	[0.015]	[0.0055]	[0.0061]	[15.679]	[24.457]	[903.65]
Number of Observations	58,915	44,427	44,427	58,915	58,915	58,915
State and Year Fixed Effects	X	X	X	X	X	X
Demographic Controls	X	X	X	X	X	X
Spline Controls	X	X	X	X	X	X
Bootstrapped Standard Errors				X	X	X

Standard Errors are in Brackets. Standard Errors are Bootstrapped for Quantile Regression with 200 repetitions.
* = Significant at 10% level, ** = Significant at 5% level
The mean and median log financial wealth on the 1990-2003 sample are 7.93 and 8.00, respectively.
The mean and median log financial wealth to income ratios on the 1990-2003 sample are -2.37 and -2.32 respectively.
The 30th, 50th and 70th percentile for Financial Wealth are $100, $1100, and $5500 respectively.
Columns I-III are estimated via two stage least squares. Columns IV -VI are estimated via a reduced form Quantile Regression on the instruments directly.
When indicated, demographic controls include a cubic polynomial in the age and earnings of the head of household, gender and marital status fixed effects, the number of children in the household, racial fixed effects, the level of education in the household, and a dummy variable indicating whether or not the spouse of the head of household was also employed. These controls absorb roughly 69% of the total variation in simulated replacement rates and 75% of the variation in benefit durations.
Spline controls replace the ordinary polynomials in age and income with flexible five and seven knot cubic splines respectively. Knots are placed for every ten years of age and twenty thousand dollars of earned income.

Tables

Table VII: Heterogeneous Response by Unemployment Probability

Column	I	II	III	IV
Dependent Variable	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income	Financial Wealth/Income
Method	IV	2 Step IV	IV	2 Step IV
Replacement Rates	-0.591	-0.4684	-0.526	-0.074
	[0.555]	[-1.232,0.503]	[0.563]	[-0.431,0.293]
Maximum Benefit Duration	...	...	-0.0229	0.000123
			[0.0151]	[-0.004,0.004]
RR * High Probability	...	-0.2127	...	-0.181
		[-1.485,0.782]		[-0.589,0.145]
Duration * High Probability	...	...	...	-0.00199
				[-0.006,0.0013]
High Probability	...	0.131	...	0.179
		[-0.332,0.686]		[-0.064,0.423]
Number of Observations	58,915	58,915	58,915	58,915
State and Year Fixed Effects	X	X	X	X
Demographic Controls	X	X	X	X
Spline Controls	X	X	X	X
Bootstrapped Standard Errors		X		X

Standard Errors are in Brackets. For two step estimation, the 95% confidence interval is in brackets.
* = Significant at 10% level, ** = Significant at 5% level
The mean and median financial wealth to income ratios on the 1990-2003 sample are 0.539 and 0.0407, respectively.
All columns are estimated via two stage least squares.

When indicated, demographic controls include a cubic polynomial in the age and earnings of the head of household, gender and marital status fixed effects, the number of children in the household, racial fixed effects, the level of education in the household, and a dummy variable indicating whether or not the spouse of the head of household was also employed. These controls absorb roughly 69% of the total variation in simulated replacement rates and 75% of the variation in benefit durations.
Spline controls replace the ordinary polynomials in age and income with flexible five and seven knot cubic splines respectively. Knots are placed for every ten years of age and twenty thousand dollars of earned income.

All specifications that include a high probability fixed effect (Column II and Column IV) are defined as follows: the high probability variable is equal to one if the probability of the head of household's unemployment is above the median probability in that year. These probabilities are estimated by an OLS regression of unemployment outcomes on the full suite of demographic controls, state and year fixed effects, and dummies for the two digit industry code where the head of household is employed. The two-step estimation procedure is bootstrapped with 100 repetitions to generate consistent standard errors.

Table VIII: Portfolio Choice

Column	I	II	III	IV	V	VI	VII	VIII	IX
Dependent Variable	Financial Wealth/Income	Liquid Wealth/Income	Non-Precautionary Wealth/Income	Financial Wealth/Income	Liquid Wealth/Income	Non-Precautionary Wealth/Income	Financial Wealth/Income	Liquid Wealth/Income	Non-Precautionary Wealth/Income
Method	IV	IV	IV	IV	IV	IV	2 Step IV	2 Step IV	2 Step IV
Replacement Rates	-0.591	0.0281	-0.126	-0.526	0.03	-0.123	-0.074	0.021	-0.0711
	[0.555]	[0.055]	[0.146]	[0.563]	[0.0554]	[0.149]	[-0.431,0.293]	[-0.739,0.145]	[-0.440,0.283]
Maximum Benefit Duration	...	...	...	-0.023	-0.0006	-0.001	0.000123	-0.0015**	0.0005
				[0.015]	[0.00062]	[0.002]	[-0.004,0.004]	[-0.003,-0.0001]	[-0.0036,0.0046]
RR * High Probability	...	...	...	...	...	...	-0.181	0.014	-0.0866
							[-0.589,0.145]	[-0.072,0.098]	[-0.491,0.247]
Duration * High Probability	...	...	...	...	...	...	-0.00199	0.0013**	-0.002
							[-0.006,0.0013]	[0.00037,0.0022]	[-0.0059,0.0013]
High Probability	...	...	...	...	...	...	0.179	-0.0427*	0.111
							[-0.064,0.423]	[-0.087,0.00299]	[-0.111,0.348]
Number of Observations	58,915	58,915	58,915	58,915	58,915	58,915	58,915	58,915	58,915
State and Year Fixed Effects	X	X	X	X	X	X	X	X	X
Demographic Controls	X	X	X	X	X	X	X	X	X
Spline Controls	X	X	X	X	X	X	X	X	X
Clustered Standard Errors	X	X	X	X	X	X			
Bootstrapped Standard Errors							X	X	X

Standard Errors are in Brackets. For two step estimation, the 95% confidence interval is in brackets.
* = Significant at 10% level, ** = Significant at 5% level
The mean and median financial wealth to income ratios on the 1990-2003 sample are 0.539 and 0.0407, respectively.
The mean and median liquid wealth to income ratios on the 1990-2003 sample are 0.118 and 0.199 respectively.
The mean and median non-precautionary wealth to income ratios on the 1990-2003 sample are 0.141 and 0.000 respectively.
Columns I-III include the replacement rate offered by unemployment insurance alone
All columns are estimated via two stage least squares.
When indicated, demographic controls include a cubic polynomial in the age and earnings of the head of household, gender and marital status fixed effects, the number of children in the household, racial fixed effects, the level of education in the household, and a dummy variable indicating whether or not the spouse of the head of household was also employed. These controls absorb roughly 69 percent of the total variation in simulated replacement rates and 75% of the variation in benefit durations.
Spline controls replace the ordinary polynomials in age and income with flexible five and seven knot cubic splines respectively.
When indicated, standard errors are adjusted for clustering at the state level.
All specifications that include a high probability fixed effect (columns VII-IX) are defined as follows: the high probability variable is equal to one if the probability of the head of household's unemployment is above the median probability in that year. These probabilities are estimated by an OLS regression of unemployment outcomes on the full suite of demographic controls, state and year fixed effects, and dummies for the two digit industry code where the head of household is employed. The two-step estimation procedure is bootstrapped with 100 repetitions to generate consistent standard errors.