Free Money? 401(k)s, Vesting, and Unemployment

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March 2004

[1]E-mail: dlove@williams.edu, phone: 413-597-3213, fax: 413-597-4045. I thank George Hall and William Brainard for their guidance and support. I thank seminar participants at the 2003 conference on Improving Social Insurance Programs, 2002 SED conference, the Board of Governors of the Federal Reserve System, the Federal Reserve Banks of Boston and Richmond, Lafayette College, Pomona College, Princeton University Inter-University Student Conference, USC Marshall School of Business, Washington and Lee University, Williams College, and Yale University. I also thank both Eric French and Hugo Benitez-Silva for computational advice. All errors are my own. JEL Classification Code E2, E6, H2.

Abstract

This paper analyzes the effects of employment risk and vesting rules on the substitution between 401(k)s and conventional savings. Nearly two-thirds of 401(k) plans include vesting rules, which stipulate a partial or complete forfeiture of employer-matched contributions in the event of a job loss that occurs before a service requirement is met. We characterize this risk by simulating a stochastic dynamic programming model that incorporates vesting and key institutional features of the 401(k). We examine the impact of vesting on participation in the 401(k), saving both inside and outside the plan, aggregate saving and welfare. We find that participation—primarily of younger workers—falls with longer vesting durations. This drop in participation is mirrored by a reduction in the substitution of 401(k) plans as a buffer against unemployment risk. The net effect on aggregate saving is small, and the welfare cost is modest.

> "If it's a matched plan, your employer is helping you become rich by adding a contribution to your account. Free Money!"
>
> —Wallstreetcity.com

1 Introduction

In the wake of the Enron debacle, the media have anchored much of their attention on the possibility of retirement accounts, such as the 401(k), losing money in the event of job loss. One reason this focus on employment risk might be well placed is that vesting rules explicitly link the 401(k) to employment status. Nearly two-thirds of 401(k) plans include vesting rules, which stipulate a partial or complete forfeiture of employer-matched contributions in the event of a job loss that occurs before a service requirement is met. This paper analyses vesting and employment risk within the framework of a dynamic programming model in which individuals choose consumption, contributions, and saving.

Simulations of the model shed light on two important questions surrounding 401(k)s. First, to what extent does vesting limit the substitution of 401(k) plans for conventional savings? Simulation results from Love (2004) indicate that 401(k) plans have the potential to substitute for precautionary saving against employment fluctuations. Results from the model in this paper demonstrate the potential of vesting to limit the substitution between accounts. Second, given the generosity of employer matching, why is participation so low among less highly compensated employees? A recent study finds that the 401(k) participation rate increases from 36 percent for individuals earning less than $15,000 to 81 percent for individuals earning more than $75,000 (Basset, Fleming, and Rodrigues, 1998). Results from our simulations suggest that when one accounts for uncertainty due to the possibility of job loss in conjunction with frequently long vesting durations, it is not clear that low participation is irrational.

Vesting rules on the 401(k) pertain only to matched contributions made by the employer. Motivated by the desire to improve employee retention, attract quality workers, and meet 401(k) eligibility requirements, firms frequently match employee contributions at rates ranging from 10 to 200 percent. Financial planning websites tend to express unmixed enthusiasm for matching, and many proclaim such matches "free money." Participants seem to agree. In a recent survey of plan participants (Investment Company Research, 2000), matching ranks as the second most compelling reason to invest in the plan, behind only "concern over retirement needs." Less well advertised is the fact that a significant portion of these matched contributions can be lost if an employee leaves a job before a vesting requirement is fulfilled. Furthermore, data on job duration and vesting lengths suggest that vesting may indeed affect a substantial number of workers. Olivia Mitchell (1999) reports that in 1997, 46 percent of plans vested fully only after five years. What percentage of employees would be expected to make it the full five years? Although data are not complete enough to answer this precisely, some indication can be found by looking at retention rates. Neumark, Polsky, and Hansen (1999) estimate the four-year retention rate for workers with tenure under two years to be around 38 percent. If vesting duration were independent of tenure,[1] this would imply that over 60 percent of these workers would not receive all of their matched contributions. Instead of "free money," matched contributions with vesting may better be described as risky assets that are perfectly correlated with employment uncertainty.

The 401(k) primarily targets retirement savings and is substantially illiquid for individuals younger than $59\frac{1}{2}$. While the tax deferred status of the 401(k) makes the plan a preferred substitute for retirement savings, the illiquidity reduces its substitutability with other forms of saving. In particular, younger employees who expect high income growth are unlikely to engage in retirement saving unless induced to do so through generous matching provisions. Results from the model suggest that without matching, the tax advantages alone of the 401(k) are an insufficient incentive to save for the young. To the extent that these younger workers finance increased contributions out of buffer-stock savings, the 401(k) plan can increase their exposure to consumption risk. With vesting, this risk is exacerbated, because the income shock is highly correlated with the possibility of forfeiture. A natural question to ask is, to what extent does vesting reduce the attractiveness of employer matching? Vesting may indeed be an effective means of increasing retention for the firm, but does it undermine the more global goal of retirement programs to increase saving?

In this paper we address these questions by focusing on the interaction of vesting rules with precautionary saving. We solve and simulate a life-cycle model that incorporates vesting and key features of the 401(k) such as withdrawal penalties, contribution limits, and matching. Previous authors (see below) have solved models of retirement plans. The main modeling innovation in the paper is the inclusion of vesting and unemployment.

The paper examines vesting from the perspective of the employee. Vesting rules and matches

[1]Of course, tenure is unlikely to be independent of vesting. For example, workers in high turnover industries might demand shorter vesting periods, or workers with a low taste for saving might trade off longer vests for higher wages.

are introduced exogenously even though these are chosen by the employer. In addition, there are no quits in the model and unemployment occurs only because of job displacement. Given that firms implement vesting rules in large part to reduce job turnover, these assumptions miss an important aspect of vesting which is employer's decision with respect to plan specifics.

Across a broad range of parameters, several trends emerge in the simulations. First, vesting rules significantly reduce participation in the 401(k). Increasing the length of the vesting period by one year reduces the number of years of participation by about three-fourths of a year. During the first decade of work, individuals pursue a strategy of waiting until the vesting requirement is met before contributing to the 401(k). Once vested, these individuals then contribute more than they would in the absence of vesting rules. It is the lower participation of the young that accounts for the drop in participation overall. Older workers actually increase their contributions in periods before fully vesting, which we interpret to be the result of an income effect associated with the lower expected amount of the match. The results on participation are likely to represent a lower bound since the model does not allow for voluntary separations. In reality, an employee who anticipated quitting before the vesting requirement was met would only contribute if the tax breaks alone were a sufficient incentive.

Second, vesting affects the degree to which 401(k) plans substitute as a buffer stock against employment fluctuations. Longer vesting durations are associated with higher saving in the outside account and lower contributions in the 401(k) for younger workers. Increasing the vesting duration from zero years to four reduces the ratio of contributions to income by between 32 and 55 percent for individuals in the first 10 years of working life. At a time when the primary motivation for saving is precautionary, vesting diminishes the substitutability of 401(k)s for conventional saving. (It is not possible to cleanly separate the precautionary motive from the lifecycle saving motive, but the precautionary motive is likely to be dominant in earlier periods of life.) For older workers, the effect is the opposite. Longer vesting durations actually increase the contribution ratios, which reflects the income effect mentioned above.

We then compute national saving rates and find that vesting has a negligible effect in the aggregate. Saving tends to fall with longer vesting durations for plausible assumptions of economic growth, but the amount is small. We also calculate the welfare costs of vesting and find they are modest. We compute equivalence measures of welfare and find that the average welfare loss generated by a vesting duration of four years amounts to roughly three percent of consumption for younger workers. Because we model neither quits nor the firm's decision, the welfare calculations are in some sense incomplete. Firms are presumably better off with vesting since it is optional. Workers who are contemplating quitting are worse off because the possibility of losing matched contributions distorts the labor decision.

The size of the matching limit plays a fundamental role in the results above. We solve the model for matching limits of both three percent and six percent of salary. At the lower matching limit, participation in the plan is increased, and the negative effect of vesting is diminished. With respect to welfare, the higher matching limit increases the welfare loss associated with longer vesting durations.

This paper builds on a body of empirical and computational research on retirement plans. The predominant mass of research relating to retirement plans empirically addresses the question of whether these plans generate new national saving. For the last twenty years, there has been an ongoing debate between economists who argue that these plans are effective at creating new saving[2] and economists who argue that the effect of the plans on saving is negligible at best.[3] This controversy is sustained both by conspicuous lacuna in the major data sources on consumption, as well as the fact that the U.S. economy is not characterized by a steady state with retirement plans (e.g., the historically recent adoption of the plan implies a participation bias favoring the young). While it is no substitute for empirical work, this computational model enables one to evaluate the impact of retirement plans within the framework of steady state analysis.

The model in this paper is in the spirit of three previous computational papers that each evaluate the effect of tax-favored saving plan on national saving. Eric Engen, William Gale and John Karl Scholz (1994) solve a multiperiod model with Individual Retirement Accounts (IRAs) and find that IRAs generate little new savings. Their result follows partly from an institutional difference between IRAs and 401(k)s. The contribution limit on the IRA is approximately one-fifth the size of that on the 401(k). Desired savings in their model almost always exceed the limit and as a consequence, the marginal incentive to save is frequently non-binding. Ayşe İmrohoroğlu, Selhattin İmrohoroğlu, and Douglas Joines (1998) model the institutional framework of IRAs in a general equilibrium life-cycle model. They find that "new" saving composes approximately nine percent of total IRA contributions. Finally, David Laibson, Andrea Repetto, and Jeremy Tobacman (1998) return to the partial equilibrium setting of Engen and Gale and model the

[2]See, for example, Steven Venti, James Poterba, and David Wise (q.v. Poterba, Venti, and Wise, 1995, 1997; and Venti and Wise, 1986, 1990, 1995), who argue that plan contributions constitute new saving.

[3]William Gale, Karl Scholz, and Eric Engen (q.v. Engen, Gale, and Scholz, 1994, 1996; and Gale and Scholz, 1994) are the chief proponents of this view.

behavior of an individual with hyperbolic preferences. Among other results, they find that hyperbolic consumers are more likely to run up against liquidity constraints. All of these papers focus on the global question of whether retirement plans increase saving. The emphasis in our paper is on the working life, and we use a computational model of 401(k)s to measure the effects of vesting on saving, contributions and welfare.

2 Matching and Vesting

2.1 Vesting in Defined Contribution Plans

Vesting policies for employer contributions[4] vary across plans and take one of three forms: immediate vesting, graduated vesting, or cliff vesting. An example of graduated vesting is a plan that vests 25 percent per year for four years. Under cliff vesting, the individual cannot access any of the matched contributions until a service requirement has been met, after which point everything vests (for example, zero percent for durations under two years, and 100 percent for durations two years or greater). According to BLS data,[5] each of the vesting categories is about equally represented across plans. In 1997, for example, 34 percent of plans had immediate vesting, 32 percent had graduated vesting, and 27 percent had cliff vesting (the remaining 7 percent had "other"). Of those plans that offered cliff vesting, 88 percent required a service duration three years or longer.[6] Of those that offered graduated vesting, 75 percent vested fully before nine years of employment. Given the prevalence of reasonably long vesting periods, it is plausible that these rules may have a significant impact on savings behavior.

The potential loss associated with vesting can be substantial. In 1998, 15 percent of all 401(k) participants would have lost some of their employer's match in the event of job loss.[7] For those plans that had some amount subject to forfeiture, the average loss amounted to nearly $6,000, which translated into an average reduction in plan savings of 33 percent.

Unlike vesting in a traditional defined benefits plan, defined contribution plans grant individuals the flexibility to choose a contribution path that mitigates the potential losses associated with

[4] Under ERISA guidelines, *employee* contributions must vest immediately in the 401(k).

[5] Source: U.S. Department of Labor, Bureau of Labor Statistics, "Employee Benefits in Medium and Large Firms, 1985-1997."

[6] ERISA vesting rules were revised in 2001 under the EGTRRA. Plans must now be fully vested before three years for cliff vesting and six years for graduated vesting. These rules took effect on 01/01/2002. The previous rules required full vesting before five and nine years respectively for cliff and graduated vests.

[7] Author's calculation from the 1998 Survey of Consumer Finances (table 3.11 in the appendix).

vesting. The optimal contribution strategy must balance a set of trade-offs. The main benefits of contributing to the plan are employer matching and lower taxes, while the primary cost is the reduced liquidity associated with the withdrawal rules on the 401(k).

At first glance, it is not obvious that vesting would have much of an impact on an individual's saving decision. After all, none of the employee's contributions are lost during unemployment, and even though the match may be lost with some probability, the expected amount of the match is still quite high. To see how vesting can still introduce a significant distortion in the saving decision, consider the case of an individual who saves primarily as a precaution against income loss due to unemployment. (In the absence of income risk, this person would like to borrow against future income.) If the individual is not fully vested, she always has the option of deferring contributions until fully vested. The main costs associated with this strategy comprise the foregone returns on both the employee and employer contributions and the increased probability of losing out on some of the employer match in the future. If there were no limits on matching or contributions, this latter cost would not arise, and missed match opportunities could always be made up in the future by shuffling savings from the outside account to the inside account. With limits, however, delaying contributions makes it more likely that the individual will save (more) in excess of the matching limit sometime in the future. While the lost returns and matches may represent substantial costs to the individual, the magnitudes are not so great as to rule out the possibility that they are surpassed by the benefits of higher liquidity.

2.2 Matching, Withdrawal Penalties, and Contribution Limits

The impact of vesting on saving depends, in part, on the limits and penalties attached to the 401(k). (The institutional details of matching, withdrawal penalties and contribution limits are discussed in Love, 2004) The withdrawal rules on the 401(k) stipulate that individuals may not take early distributions from the 401(k) except under special circumstances, the most important of which is unemployment. In the event of a job separation, an individual is allowed to withdraw from the plan, but the withdrawn amount is penalized at 10 percent and taxed as ordinary income.

Employer matching is firm specific and consists of both a match rate (as a fraction of contributions) and a match limit (as a fraction of salary). Both elements play a role in the trade-offs associated with vesting. It is possible that the match rate can offer a sufficient incentive for the individual to save against employment risk in 401(k) account.

There is both an income and a substitution effect of matching on contributions, and they can work in opposite directions. On the one hand, higher match rates decrease the relative price of saving in the 401(k) and therefore tend to increase desired saving in the plan. On the other hand, they also reduce the amount of saving needed to acquire the same level of wealth, which tends to reduce desired saving in the plan. The net effect of matching in a model with vesting will depend, in part, on the relative sizes of these income and substitution effects.

In the presence of vesting, the effect of the match limit on contributions can be subtle. A large component of the opportunity cost of foregoing matching in a given period is the potential inability to make up for it in later periods. During the build up for retirement, an individual is more likely to have desired saving in excess of the match limit if she contributed less in earlier periods. The lower the matching limit, the earlier an individual will have to begin saving in order to take full advantage of the match. Because of this, the matching limit provides an incentive to even out contributions over time. In the context of vesting, one would expect lower match limits to increase the cost of delayed contributions (and therefore the costs of vesting itself) since individuals are less able to "catch up" after the vesting requirement has been met.

The elective contribution limit (equal to $12,000 in 2003) introduces a distortion similar to that of the matching limit. In this case, delayed contributions make it more likely that the individual will face a binding contribution limit some time in the future. Because the elective limit is not tied to income, as is the case with the firm matching limit, its effect should be more important for individuals with higher expected income.

The interaction between vesting rules and match rates is likely to depend on lifecycle-specific parameters such as the discount rate and risk aversion. The computational model laid out in the next section provides a more realistic framework with which to study the effects of vesting and matching on precautionary savings.

3 Model of 401(k)s with Vesting

This section develops a model of 401(k)s with vesting rules and the possibility of forfeiture. Matched portions of individual contributions to the 401(k) do not vest immediately but instead vest according to a schedule that depends on employee tenure. The unvested portion of matched contributions is subject to forfeiture in the event of unemployment. Assets in each account earn the same stochastic rate of return and are subject to non-negativity constraints. In each period of life, the individual forms expectations about the next period's income, returns and probability of survival.

Preferences The framework is a standard lifecycle model with intertemporal utility maximization. The consumer maximizes the following utility function over a finite, but uncertain, lifetime:

$$U_t = E_t \sum_{i=t}^{T} \left(\prod_{j=0}^{i} p_{t+j} \right) \beta^{i-t} u(C_i) \tag{1}$$

where β is the discount factor, C_t is real consumption, E_t is the expectations operator, T is the maximum life-span, and $p_t = prob(alive_t \mid alive_{t-1})$ is the conditional survival probability at period t. The period utility function is taken to be of constant relative risk aversion form:

$$u(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma} \tag{2}$$

where γ is the coefficient of relative risk aversion, and $\frac{1}{\gamma}$ is the intertemporal elasticity of substitution.

Income process Income uncertainty is generated by probabilistic unemployment. The logarithm of income at time t is given by

$$\ln(Y_t) = \begin{cases} emp_t g(\mathbf{Z}_t) + (1 - emp_t)\ln(UI_t) & \text{if } t < t^{ret} \\ g(\mathbf{Z}_t) \quad \text{if } t \geq t^{ret} \end{cases} \tag{3}$$

where $g(\mathbf{Z}_t)$ is a log-income profile, emp_t is an indicator variable that equals one if the individual is employed and zero otherwise, and UI_t is unemployment insurance that is modeled the same as above. In the event that an individual remains unemployed in two or more successive periods, unemployment insurance is the amount received in the first period of unemployment. The probability of being unemployed depends on age and education and is assumed to be independent of last-period's state. In each period, the probability attached to a particular employment state, $\pi(emp)_{it} = prob(emp_{it} = emp)$, is a function of age and education (captured in the individual subscript).

Employment duration and vesting rules The vesting rules depend on the individual's tenure with the firm. Let d_t denote the duration of an individual's employment with a given firm. Duration is a function of time t and the employment state emp_t:

$$d_t = \begin{cases} d_{t-1} + 1 & \text{if } emp_t = 1 \text{ and } t < t^{ret} \\ 0 & \text{if } emp_t = 0 \quad \text{or} \quad t \geq t^{ret}. \end{cases} \tag{4}$$

Denote by α_t the fraction of matched contributions that vests in period t. The vesting fraction varies depending on the vesting schedule, and the model allows for both cliff and graduated vesting. Let d^* denote the duration at which the employee is fully vested into the 401(k) plan. Under cliff vesting, the vesting fraction is given by

$$\alpha_t = \begin{cases} 1 & \text{if} \quad d_t \geq d^* \\ 0 & \text{if} \quad d_t < d^*. \end{cases} \tag{5}$$

Under graduated vesting, a fraction of the matched contributions vests each period:

$$\alpha_t = \frac{1}{d^*} d_t.$$

So, for example, under a five-year vesting schedule, 20 percent vests after the first year, 40 percent after the second, etc. In the event of a job separation, duration is zero, and any unvested matched contributions disappear.[8]

Asset constraints In order to make the problem tractable, each account is assumed to share the same before-tax rate of return R_t (the after-tax rates of return will, of course, differ). R_t is assumed to be distributed lognormally. Assets in the 401(k) account accumulate as follows:

$$S_{2,t+1} = R_t S_{2,t} + X_t + \alpha_t \left(m * \min(X_t, \psi Y_t) + M_t \right) \tag{6}$$

where X_t is the employee's contribution to the 401(k), M_t is the amount of the employer's matching contributions that did not vest the period before, Y_t is income, m is the rate at which the employer matches contributions, ψ is the maximum fraction of income the employer is willing to match, and α_t is the fraction of the matching contributions that vests in period t. Unvested matched contributions evolve as follows:

$$M_{t+1} = \begin{cases} R_t(1 - \alpha_t) \left[M_t + m * \min(X_t, \psi Y_t) \right] & \text{if} \quad emp_t = 1 \\ 0 & \text{if} \quad emp_t = 0, \end{cases} \tag{7}$$

[8]In the paper, duration always refers to the number of years an individual must be employed before vesting completely.

where the match rate m applies only to positive contributions. Equation (7) reflects the property that any unvested portion of the matched contributions is lost in the event of a job separation. In the case of cliff vesting, α_t will be equal to zero if tenure is below the vesting duration and equal to one otherwise. Once the employee is vested, matches enter immediately into the 401(k) account, in which case $S_{2,t+1} = R_t S_{2,t} + X_t + m * \min(X_t, \psi Y_t)$.

The equation for the unsheltered account accumulation is given by:

$$S_{1,t+1} = R_t S_{1,t} + Y_t - C_t - X_t - taxes_t - pen_t, \tag{8}$$

where $taxes_t$ and pen_t denote respectively taxes and the withdrawal penalty.

3.1 Individual's Problem with Vesting

At the beginning of period t, the individual observes realizations of employment status and returns, which determine the level of savings in both accounts, the size of the unvested match, and income. The individual then decides how much to consume, how much to contribute to the 401(k) account, and how much to save in the unsheltered account. The last decision—how much to save in the unsheltered account—is determined by the first two choices.

The set of state variables for the problem is $\Omega_t = \{S_{1,t}, S_{2,t}, M_t, emp_t, d_t, t\}$. Income Y_t is determined by the employment state emp_t and time trend $g(\mathbf{Z}_t)$. The control variables are $\{C_t, X_t\}$. The value function for the consumer's problem is given by

$$V_t(\Omega_t) = \max_{C_t, X_t} \left[u(C_t) + \beta p_{t+1} E_t V_{t+1}(\Omega_{t+1}) \right] \tag{9}$$

subject to

$$S_{1,t+1} = R_t S_{1,t} + Y_t - C_t - X_t - taxes_t - pen_t$$

$$S_{2,t+1} = R_t S_{2,t} + X_t + \alpha_t \left(m * \min(X_t, \psi Y_t) + M_t \right)$$

$$M_{t+1} = \begin{cases} R_t(1-\alpha_t)\left[M_t + m * \min(X_t, \psi Y_t) \right] & \text{if } emp_t = 1 \\ 0 & \text{if } emp_t = 0 \end{cases}$$

$$S_{1,t} \geq 0, \; S_{2,t} \geq 0$$

$$X_t \leq L \;\; \text{if } t < t^{ret}$$

$$X_t \leq 0 \;\; \text{if } t \geq t^{ret}$$

The expectation in equation (9) is taken over employment uncertainty. Specifically,

$$E_t \left[V_{t+1}(\Omega_{t+1}) \right] = \sum_{emp=0,1} \int \pi(emp)_{t+1} V_{t+1}(\Omega_{t+1}) dF(R_t), \tag{10}$$

where $F(.)$ is the distribution of returns,[9] and income and duration at time $t+1$ are functions of the employment state at $t+1$. The institutional features of the 401(k) that make the plan interesting to study also introduce complexities in the computational solution. In particular, the contribution and matching limits introduce potential nonlinearities in the value function. The general approach in this paper is to use discrete space methods and interpolation to solve the model from the last period backwards. At each time period, the value function and corresponding decision rules are computed at a predetermined set of points in the state space. We then use linear interpolation between points and extrapolation beyond points in order to construct functions that are defined at all points in the state space. These interpolated functions are then used in the next period's optimization problem. Starting with period T, equation (9) is solved recursively to yield consumption and saving functions, which take duration, the size of the unvested match, and asset levels in each account as their arguments.

3.2 Data and Calibration

The income process used in this paper does not include any stochastic component to labor income except for the possibility of unemployment. As such, we use only the mean income profiles from the estimated earnings regressions (reported in table 1).

Job separation in the model is taken to be exogenous. In the presence of vesting, an endogeneity issue arises with respect to quits, since workers would be likely to delay quitting in order to secure more of the vest. This paper considers the event of involuntary separation, which we approximate with data on job displacement. We take the probabilities of displacement from a paper by Henry Farber (1997), which reports displacement rates from the Displaced Worker Survey supplement to the Current Population Survey. Farber's numbers correspond to the probability of job loss occurring at least once within a three year time period. We then convert these into one-year probabilities by assuming that the rate of displacement is constant across years. Table 2 displays the result.

The emphasis in this paper is on the impact of vesting durations, and UI is mostly treated as a constant. For most simulations, we use a UI replacement rate of 30 percent, but we test the sensitivity of this specification by solving the model with a UI rate of 50 percent.

Individuals begin their working life at age 20 and live to a maximum of 85 years. For all ages under 85, we calculate the conditional survival probabilities using mortality tables from the

[9] we approximate the integral over returns using Gauss-Hermite quadrature of degree 6.

Table 1: Coefficient Estimates for Income Profiles

Independent Variable	*Education <12*	*Education 12-15*	*Education >15*
Working Households			
Family Size	0.062 (0.016)	0.017 (0.008)	0.037 (0.010)
Age	0.201 (0.084)	0.099 (0.045)	0.029 (0.053)
$\text{Age}^2/100$	−0.358 (0.195)	−0.035 (0.106)	−0.468 (0.114)
$\text{Age}^3/10,000$	0.203 (0.145)	−0.089 (0.080)	0.241 (0.079)
Constant, UE, and Cohort	6.749	7.844	6.749
Retired Households			
Family Size	−0.078 (0.029)	−0.073 (0.042)	0.059 (0.088)
Age	0.000 (0.000)	0.015 (0.006)	−.044 (0.008)
Constant, UE, and Cohort	8.947	9.867	13.010

Source: Author's estimates using the 1988-1997 Michigan Panel Study of Income Dynamics The dependent variable is the logarithm of income in year 2000 dollars. Standard errors included below.

National Center for Health Statistics US Life Tables, 1999. We set the discount factor β equal to 0.967, which together with the survival probabilities tends to offset the effect of the return on intertemporal consumption. Pre-tax gross returns on both accounts are drawn from a lognormal distribution with a mean of 5 percent and standard deviation of 15 percent. The assumption that both accounts share the same mean return and risk is systematically incorrect, since individuals have an incentive to place heavily taxed assets inside the plan.

The 401(k) parameters are as follows The annual contribution limit is $10,500, which was the elective limit in 2000. The penalty rate $\kappa(emp_t)$ is taken to be 100 percent on early withdrawals

Table 2: Displacement probabilities by age and education

Age	*Education <12*	*Education 13-15*	*Education >15*
20-24	0.076	0.055	0.039
25-34	0.068	0.052	0.035
35-44	0.058	0.043	0.030
45-54	0.053	0.039	0.028
55-64	0.057	0.039	0.027

Source: Author's calculation using results from Tables A-3 and A-4 in Farber (1997).

Table 3: Summary of Parameter Choices

β	0.967
γ	3
R	1.05
σ_R	0.15
m	25% to 50%
ψ	3% to 6%
$k(0)$	10%
$k(1)$	100%
UI	30% to 50%
d^*	0 to 4 years

before retirement if the individual is employed and 10 percent if the individual is unemployed. As discussed above, the matching function is likely to be of central importance to the interaction between vesting and saving. We simulate the model for match rates of 25 percent and 50 percent and matching limits of 3 percent and 6 percent of salary.

The main policy experiment involves changing the maximum vesting duration. Although it is possible to solve the model for a graduated vesting scheme, all results in this paper pertain to the case of cliff vesting. We solve the model for all vesting durations between zero years (immediate vesting) and 4 years. It is important to look at different durations since the impact on saving is unlikely to be a linear function of duration. Table 3 summarizes the parameter choices in the baseline specification.

4 Results

The results focus on the extent to which vesting affects four topics of interest: participation in the 401(k), account substitution, aggregate saving and welfare. The contribution and matching limits play a fundamental role in shaping the time path of saving and consumption, and we also include measures of their effect on results pertaining to the four areas above.

The solution method is obtained using discrete space methods. Starting from the last period backwards, we compute the value functions for a discrete set of points in the state space. During employment, that means solving for each point on a grid of employment, unvested matches, wealth in the 401(k) and wealth in the outside account. We interpolate between points on the value function and use quadrature for the expectation over returns. Once solved, we then simulate 10,000 life histories for each education group that differ with respect to returns, employment, and mortality. Individuals begin life with an equal probability of being at any tenure between zero (the first year of employment) and the vesting duration. Since the model begins at the start of the work life, all tenures should technically begin at zero. We randomize over tenure because it allows me to characterize the interaction between vesting and tenure for younger workers as well as older. If everyone started at zero, the variation in tenure would not be large enough among the youngest workers to identify the effects of different durations by age and tenure.

4.1 Participation in the 401(k)

There is no distinction in the model between not participating in the 401(k) and participating but not contributing. We therefore define participation as follows. An individual is counted as a participant in the model once she contributes more than $20 to the plan during a given tenure. So, for example, if an individual contributes $1,000 to the plan during the first year of employment but zero thereafter, she is a participant for the entire tenure.

Table 4 displays the average years of participation for different vesting durations, match limits, and education groups. Participation declines monotonically with longer vesting durations for each of the three education groups. The reduction in participation increases as the education level falls. At a match limit of six percent, increasing the duration from zero to three years reduces participation of dropouts by about one and a half years. The corresponding reduction in participation for college graduates is less than a year. One explanation for this has to do with the curvature of the income profiles. The lifecycle saving motive becomes dominant roughly at the point where current income rises above permanent income. Individuals whose income profiles exhibit a lot of curvature are likely to move rapidly from a state in which current income is far below permament income to one in which current income is far above permanent income. College and high school graduates have the most curvature on their expected income profiles and therefore are less likely to adjust saving in response to a change in the vesting duration.

The other trend to notice in table 4 is the influence of the matching limit on participation. For each combination of duration and education, a reduction in the match limit of 50 percent is associated with a marked increase in participation. Lower matching limits effectively increase the cost of deferring contributions, since individuals are less able to compensate by contributing more matched dollars in the future. This gives individuals an incentive to even out contributions over time. In the context of vesting, this incentive diminishes the importance of durations to participation.

Table 4: Average Participation (in years) by Vesting Duration

Education	*Match Limit*	*dur = 0*	*dur = 1*	*dur = 2*	*dur = 3*	*dur = 4*
<12	3%	39.90	39.46	38.67	38.23	37.64
	6%	38.05	37.80	37.21	36.60	35.02
12–15	3%	41.07	40.85	40.46	40.16	39.49
	6%	39.10	38.56	38.48	37.96	37.10
>15	3%	39.94	39.92	39.43	38.89	37.58
	6%	38.55	38.51	38.34	37.87	36.04

Source: Author's simulations. The table displays the average number of years an individual contributed more than $20 to the 401(k) plan for different vesting durations. The models were simulated with the following parameter specifications: match rate = 25%, match limit =3% to 6%, penalty rate when employed = 100%, penalty rate when unemployed = 30%, and CRRA = 3.

By simply looking at the table, it is not clear where in the lifecycle the drop in participation is occurring. During the period in which saving for retirement is the dominant motive, it seems less likely that the benefits of delaying participation would outweigh the costs in terms of foregone matching and returns. More likely, the drop in participation is accounted for primarily by the young. The results, below, on contributions and account substitution suggest that this is indeed the case.

The effect of vesting on precautionary saving can be seen by looking at a single simulation of the model. Figure 1 depicts a single simulation of the model for high school graduates. In this simulation, tenure begins at zero, and there is one unemployment spell that occurs at age 26. Contributions do not begin until age 22, when the individual fully vests in the plan. Between ages 22 and 25, saving in the other account falls as contributions rise. Then, at age 26, an unemployment spell leads to a reduction in consumption and saving in both accounts. This event resets tenure to zero, and once again, the individual defers contributions until the point of full vesting. Contributions then remain very close to the matching limit until age 32, when the lifecycle saving motive becomes increasingly important.

4.1.1 Matching Limit

The results above indicate that the size of the matching limit has a sizable effect on participation in the 401(k). Matching limits introduce a kink in the marginal decision to save in a 401(k). In order to get a sense of how important this kink is to different types of savers, we compute the

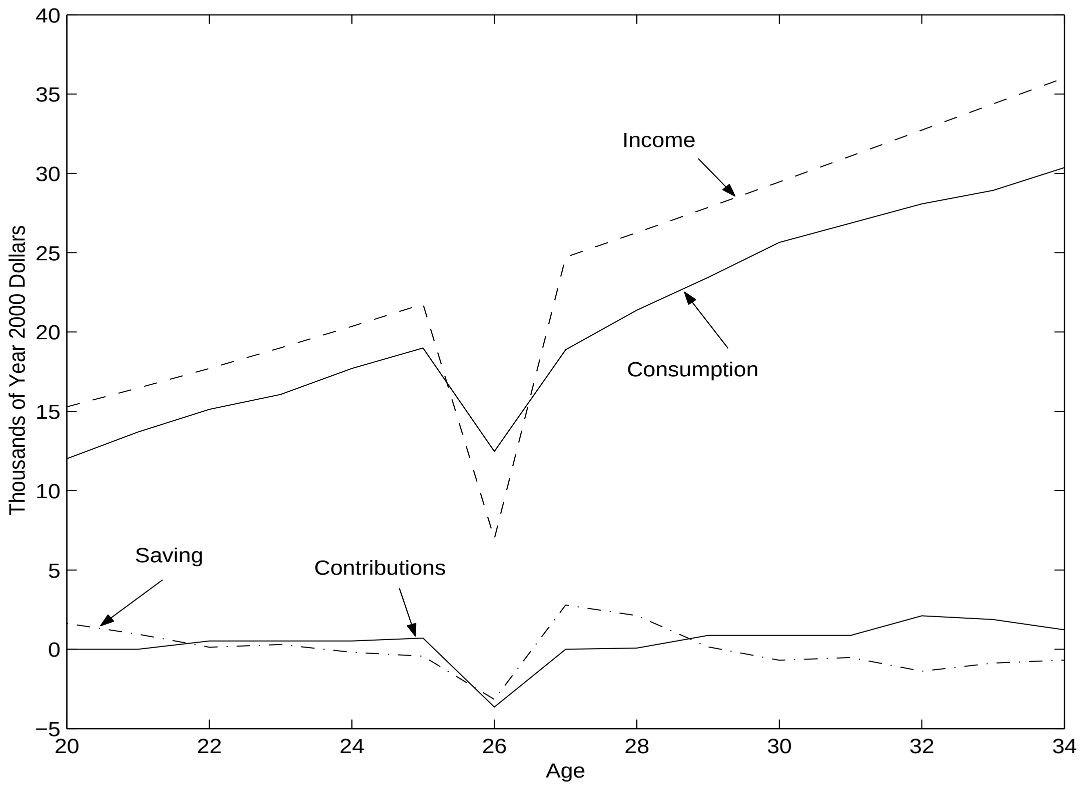

Figure 1: Single Simulation of the Model for a High School Graduate—First 15 Years

Table 5: Average Years Contributing at Match Limit by Vesting Duration

Education	*Match Limit*	*dur = 0*	*dur = 1*	*dur = 2*	*dur = 3*	*dur = 4*
<12	3%	9.25	8.86	8.52	7.95	7.56
	6%	8.78	9.06	9.38	9.79	9.82
12–15	3%	6.52	6.41	5.81	5.36	5.01
	6%	4.43	5.48	5.77	5.88	5.36
>15	3%	4.51	4.23	4.18	4.03	3.89
	6%	4.46	4.83	4.25	4.21	4.19

Source: Author's simulations. The table displays the average number of years an individual contributed between 95% and 105% of the match limit for different vesting durations. The models were simulated with the following parameter specifications: match rate = 25%, match limit =3% to 6%, penalty rate when employed = 100%, penalty rate when unemployed = 30%, and CRRA = 3.

average number of years an individual of a given educational type contributes between 95 and 105 percent of the matching limit. Table 5 displays the results.

The only clear relationship in the table is the inverse relationship between education and the number of years contributing near the matching limit. This is again a function of the differences in the curvature of the income profiles. High school and college graduates move comparatively rapidly from a state in which desired saving is low to one in which desired saving is high, which reduces the length of time the matching limit is likely to "bind."

The relationship between vesting and the matching limit appears somewhat jumbled. Dropouts and high school graduates spend less time at the matching limit for longer durations when the limit is low, while the reverse is true when the limit is high. For college graduates, longer vesting durations at a match limit of six percent do not even have a monotonic effect. Nevertheless, it is possible to make some sense out of the results. From above, it is apparent that participation declines with duration. As will be seen in the next section, this can actually increase contributions due to a "catch up" effect, whereby individuals compensate for lower saving before vesting with higher saving after. Thus, even though the total number of years of participation is lower with longer durations, the years in which desired contributions reach the higher match limit might be higher. At the lower matching limit, higher durations can have the opposite effect if contributions would have been close to the match limit without vesting. In this case, the "catch up" effect pushes contributions over the limit, reducing the number of years spent contributing there. It is possible that these two effects are also behind the inconsistent results for college graduates.

At the lower matching limit, shorter durations consistently correspond with more years at the matching limit. This result is related to the finding of higher participation at lower match limits. In order to optimize the amount of matched contributions, it is necessary to contribute earlier in life.

4.2 Contributions and Saving

Longer vesting durations reduce the expected return on each dollar of matched contributions. The effect this has on saving and contributions depends on three things: an income effect, a substitution effect and the dominant saving motive. The substitution effect of vesting reduces desired contributions, because the expected return is lower. The income effect reduces desired consumption in all periods and therefore increases desired saving in one, or both, of the accounts. The net effect on contributions and saving depends, finally, on the extent to which individuals are saving as a precaution against income fluctuations rather than to accumulate lifecycle savings (e.g. for retirement). In the model, both motives are necessarily commingled, and it is impossible to separate them.[10] Nevertheless, these motives can be expected to change in relative magnitude over the lifecycle, with the precautionary motive dominating in earlier years and the retirement motive dominating in later years. When the precautionary motive prevails, the attraction of 401(k) contributions is reduced because of the relative illiquidity of the plan. When retirement saving becomes more important, however, the match and tax-free returns make the account the preferred saving vehicle, even in the presence of vesting. We evaluate the net result of these three effects on contributions by looking at simulated contributions conditional on tenure.

4.2.1 Contributions by Tenure

Table 6 reports the average ratios of contributions to income by tenure, education and age for a vesting duration of four years. The model was solved with a match equal to 25 percent up to six percent of salary, a UI replacement rate of 30 percent, and a CRRA parameter equal to three. Across all educations, contribution ratios for the youngest group fall with lower tenure. The first 10 years of life are a period in which the precautionary motive is dominant. It is evident that the potential forfeiture of the match sufficiently reduces the incentive of the 401(k) such

[10] Indeed, this will always be the case in a lifecycle model with income uncertainty and preferences that allow for a precautionary saving effect. Carroll (1994) isolates the precautionary effect in his permanent income hypothesis model of consumption by ignoring retirement and assuming a constant growth rate of income in excess of the discount factor times the expected real return, but this ignores the hump in income associated with lifecycle models.

Table 6: Contributions Over Income by Tenure (duration = 4)

		tenure=0	tenure=1	tenure=2	tenure=3	tenure=4	tenure=all
Education	Age	X/Y^a	X/Y	X/Y	X/Y	X/Y	X/Y
<12	20-29	0.0000	0.0000	0.0035	0.0301	0.0377	0.0219
	30-39	0.0169	0.0323	0.0546	0.0603	0.0605	0.0304
	40-49	0.0714	0.0715	0.0715	0.0717	0.0717	0.0669
	50-64	0.0397	0.0419	0.0449	0.0470	0.0466	0.0448
12–15	20-29	0.0000	0.0000	0.0000	0.0160	0.0162	0.0137
	30-39	0.1110	0.0794	0.0591	0.0556	0.0551	0.0499
	40-49	0.1795	0.1739	0.1712	0.1721	0.1750	0.1662
	50-64	0.1578	0.1603	0.1615	0.1601	0.1605	0.1547
>15	20-29	0.0027	0.0139	0.0145	0.0247	0.0267	0.0190
	30-39	0.0676	0.0586	0.0486	0.0339	0.0239	0.0153
	40-49	0.1067	0.1029	0.1032	0.1034	0.1035	0.0972
	50-64	0.1096	0.1109	0.1120	0.1144	0.1143	0.1119

Source: Author's simulations. The table displays ratios of 401(k) contributions to non-asset income for different age/education combinations. Ratios are reported for tenures of zero to four, as well as for the average for all tenures. The models were simulated with the following parameter specifications: match rate = 25%, match limit = 6%, penalty rate when employed = 100%, penalty rate when unemployed = 30%, and CRRA = 3. The maximum vesting period is four years.

a. X/Y is the average ratio of 401(k) contributions to non-asset income for each age group, conditional on employment.

that individuals delay contributions at low tenures. A distinct "catch up" effect occurs near the point of full vesting, and contributions rise above average. The incentive to contribute more than average at vesting arises because there is always a possibility the individual will become unemployed and therefore lose the opportunity to make up for lost matches.

After the first 10 years of life, the relationship between tenure and contributions changes for high school and college graduates. Instead of contributing *less* at lower tenures, they contribute more. As discussed above, this probably reflects the dominance of the income effect of vesting. For a displacement probability of five percent, there is roughly a 20 percent chance that matches made in the first year of work will be lost due to unemployment. Individuals in the model are risk averse and react by increasing contributions above average. The relatively flat and low income profile of dropouts, on the other hand, means that they are more likely to be inframarginal with respect to both the matching and contribution limits and therefore better able to recover lost contributions. For dropouts, the substitution effect of vesting appears to outweigh the income

Table 7: Contributions and Saving as Ratios to Income (match limit = 0.06)

		dur =0		dur =1		dur =2		dur =3		dur = 4	
Edu	Age	X/Y	S/Y	X/Y	S/Y	X/Y	S/Y	X/Y	S/Y	X/Y	S/Y
<12	20-29	0.049	0.003	0.044	0.004	0.039	0.007	0.036	0.008	0.022	0.017
	30-39	0.029	0.014	0.030	0.014	0.031	0.013	0.030	0.012	0.030	0.007
	40-49	0.066	0.049	0.066	0.049	0.066	0.050	0.066	0.048	0.067	0.049
	50-64	0.055	0.075	0.054	0.076	0.053	0.079	0.052	0.079	0.045	0.088
12–15	20-29	0.039	0.002	0.035	0.003	0.033	0.005	0.031	0.006	0.014	0.017
	30-39	0.041	0.002	0.042	0.002	0.043	0.000	0.043	0.000	0.049	-0.008
	40-49	0.165	0.021	0.165	0.021	0.166	0.022	0.166	0.021	0.166	0.021
	50-64	0.160	0.017	0.157	0.014	0.159	0.015	0.157	0.015	0.155	0.017
>15	20-29	0.028	0.000	0.028	0.000	0.026	0.001	0.025	0.001	0.019	0.004
	30-39	0.014	0.003	0.015	0.003	0.015	0.003	0.015	0.003	0.015	0.003
	40-49	0.096	0.009	0.096	0.009	0.096	0.009	0.096	0.009	0.097	0.009
	50-64	0.115	0.053	0.115	0.051	0.115	0.052	0.116	0.051	0.112	0.055

Source: Author's simulations. The table displays ratios of conventional savings and 401(k) contributions to non-asset income for different age/education combinations. The models were simulated with the following parameter specifications: match rate = 25%, penalty rate when employed = 100%, penalty rate when unemployed = 10%, and CRRA = 3.

a. S/Y is the average ratio of conventional saving to non-asset income for each age group, conditional on employment.

b. X/Y is the average ratio of 401(k) contributions to non-asset income for each age group, conditional on employment.

effect.

4.2.2 Account Substitution

Table 7 reports the average ratios of conventional saving and 401(k) contributions to income for different vesting durations. The first thing to notice in the table is the low level of saving for individuals under age 40. The maximum saving rate in this period is 1.7 percent for dropouts. Saving in this model is done either to buffer against employment risk or for lifecycle saving. Once an individual is fully vested, 401(k) contributions appear to be the preferred form of saving for both motives. At a vesting duration of zero, conventional saving effectively vanishes. Saving rises in later years both to build up wealth for retirement and in order to maintain higher consumption when income falls toward the end of the working years.

Longer vesting durations limit the degree to which contributions substitute as a buffer against

Table 8: Contributions and Saving as Ratios to Income (match limit = 0.03)

		dur =0		dur =1		dur =2		dur =3		dur = 4	
Edu	Age	X/Y	S/Y	X/Y	S/Y	X/Y	S/Y	X/Y	S/Y	X/Y	S/Y
<12	20-29	0.025	0.015	0.024	0.016	0.022	0.017	0.020	0.018	0.014	0.023
	30-39	0.025	0.011	0.025	0.011	0.025	0.010	0.026	0.009	0.026	0.007
	40-49	0.065	0.053	0.065	0.053	0.065	0.053	0.065	0.053	0.065	0.053
	50-64	0.036	0.099	0.035	0.099	0.035	0.099	0.035	0.100	0.033	0.102
12–15	20-29	0.023	0.009	0.023	0.010	0.021	0.011	0.020	0.012	0.014	0.017
	30-39	0.038	0.001	0.038	0.000	0.039	-0.000	0.040	-0.001	0.043	-0.004
	40-49	0.172	0.020	0.171	0.020	0.171	0.020	0.172	0.021	0.169	0.023
	50-64	0.152	0.024	0.152	0.024	0.150	0.026	0.151	0.025	0.150	0.028
>15	20-29	0.025	0.001	0.024	0.002	0.022	0.003	0.021	0.004	0.015	0.007
	30-39	0.016	0.002	0.016	0.002	0.017	0.002	0.017	0.002	0.019	-0.000
	40-49	0.094	0.011	0.094	0.011	0.094	0.011	0.095	0.011	0.095	0.011
	50-64	0.112	0.061	0.111	0.061	0.111	0.059	0.111	0.060	0.109	0.063

Source: Author's simulations. The table displays ratios of conventional savings and 401(k) contributions to non-asset income for different age/education combinations. The models were simulated with the following parameter specifications: match rate = 25%, penalty rate when employed = 100%, penalty rate when unemployed = 10%, and CRRA = 3.

a. S/Y is the average ratio of conventional saving to non-asset income for each age group, conditional on employment.

b. X/Y is the average ratio of 401(k) contributions to non-asset income for each age group, conditional on employment.

unemployment. Increasing the vesting duration from zero years to four results in 55 percent, 64 percent and 32 percent reductions in the contribution ratio for dropouts, high school graduates and college graduates, respectively. Saving in the outside account increases from about zero to 0.5 percent for college graduates and to about 1.5 percent for dropouts and high school graduates. The relationship between vesting and substitution is less pronounced for older workers and even follows the reverse pattern for high school graduates of ages 30 to 39. As argued above, this is probably attributable to the income effect of vesting.

Table 8 reports contribution and saving ratios for an economy with a matching limit of three percent. The qualitative results are similar to those obtained with the larger matching limit, but the amounts differ substantially. Even for short vesting durations, conventional saving is relatively high—approximately five times larger than in the economy with the higher limit for younger workers. For this group, it is apparent that desired saving is sufficiently in excess of the matching limit to cause the residual to end up in other saving.

Table 9: Aggregate Saving (percent) by Duration and Match Limit

	dur=0		*dur=1*		*dur=2*	
$n+g$	$\psi = .03$	.06	.03	.06	.03	.06
.00	8.87	8.84	8.82	8.85	8.79	8.86
.01	9.96	9.96	9.93	9.98	9.90	9.99
.02	10.52	10.55	10.49	10.56	10.47	10.58
.03	10.63	10.71	10.61	10.71	10.60	10.72
.04	10.40	10.53	10.39	10.52	10.38	10.52
.05	9.94	10.11	9.92	10.09	9.92	10.07
.06	9.33	9.55	9.32	9.52	9.32	9.47
.07	8.63	8.98	8.63	8.86	8.63	8.79
.08	7.91	8.27	7.90	8.18	7.90	8.08

Source: Author's simulations. The table displays the aggregate saving rate for combinations of vesting durations, match limits, and total growth rate (population + economic). CRRA = 3.

4.3 Aggregate Saving

We aggregate the economy in an overlapping generations framework in which the growth rate of real variables is cohort specific. Table 9 displays aggregate saving rates for economies with vesting durations ranging from zero to two years and matching limits of three percent and six percent. The results for the remainder of the vesting durations show a negligible effect on aggregate saving for all levels. This is not entirely surprising given that the effect of vesting on individual saving rates can work in opposite directions depending on the age in the lifecycle. For a match limit of three percent, vesting appears to reduce (slightly) aggregate saving for most growth rates. For a match limit of six percent, saving is reduced for higher growth rates but increased for lower growth rates.

4.4 Utility Loss of Vesting

Even though vesting appears to have a minor effect on aggregate saving, it can still diminish welfare. In order to calculate the impact of different vesting durations on welfare, we compute equivalence measures of utility loss. For each age, we find the additional amount of wealth it would require to make an individual indifferent between remaining in an economy with vesting of a given duration and moving to one without vesting. The welfare calculations are made from the perspective of an individual with a tenure of zero. This overstates the welfare cost of vesting to the extent that it overrepresents lower tenures, but the effect on the calculations is minor for all but the oldest workers, who may never actually vest before retirement. Table 10 reports the

Table 10: Welfare Loss by Duration and Match Limit

		dur =*1*		*dur* =*2*		*dur* =*3*		*dur* = *4*	
Education	*Age*	$\psi = .03$	.06	.03	.06	.03	.06	.03	.06
<12	20-29	0.51	1.19	1.06	2.32	1.64	3.25	2.12	4.34
	30-39	0.39	0.54	0.96	1.17	1.72	1.81	2.45	3.04
	40-49	0.17	0.27	0.50	0.55	0.89	0.81	1.59	1.04
	50-64	0.12	0.25	0.36	0.51	-0.71	0.82	1.05	1.08
12–15	20-29	0.68	0.81	1.18	1.49	1.30	2.11	1.59	3.17
	30-39	0.51	0.37	1.08	0.75	0.97	1.10	1.15	1.73
	40-49	0.22	0.15	0.40	0.22	0.25	0.28	0.19	0.29
	50-64	0.72	0.26	1.09	0.73	0.70	1.32	1.44	2.17
>15	20-29	0.40	0.57	0.82	1.33	1.14	1.86	1.65	2.76
	30-39	0.17	0.17	0.34	0.29	0.40	0.38	0.84	0.71
	40-49	0.04	0.06	0.02	0.06	0.00	0.01	0.00	0.00
	50-64	0.17	0.35	0.46	0.93	0.74	1.74	1.35	2.77

Source: Author's simulations. The table displays average equivalence measures of welfare. The numbers represent the amount of additional wealth, expressed as a percent of consumption, it would require to make an individual of a given age indifferent between an economy with vesting and one without. The models were simulated with the following parameter specifications: match rate = 25%, penalty rate when employed = 100%, penalty rate when unemployed = 10%, and CRRA = 3.

average welfare cost, as a percent of consumption, for different ages and educations.

The welfare cost of vesting is proportionately highest for dropouts. The average wealth increase required to make dropouts in their first 10 years of work indifferent between an economy with a four year vest and one without a vest is about 4.3 percent of consumption. The equivalent figures for high school and college graduates are 3.2 percent and 2.8 percent respectively. This result follows partly from the fact that lower education groups have higher probabilities of job loss and therefore a greater likelihood of forfeiting their matched contributions. At the lower matching limit of three percent, the welfare cost is reduced by as much as 50 percent, which is not surprising, given that a smaller portion of firm contributions are at stake.

Overall, the welfare costs are modest. The primary reason welfare costs of vesting are not larger is that individuals strategically time contributions to limit the costs of vesting. Younger individuals wait until they are nearly fully vested before contributing and "catch up" afterwards. In contrast, older workers react to the reduced expected value of matching by increasing contributions at lower tenures. Without vesting, individuals would better be able to smooth contributions over time, but the overall cost is small.

Of course, these welfare results depend very much on the presumed sophistication of the investor. In order to get a sense of the welfare costs associated with less-than-optimal behavior, we relax the assumption of rationality in one respect and assume individuals are blind to the existence of vesting rules. These are otherwise rational individuals who are surprised to learn that their matched contributions can be subject to forfeiture if they lose their job. Here, the welfare costs are much larger. Avoiding ignorance in this economy is worth $6,300 in first period consumption for an individual with a high school education. In light of this finding, it is apparent that any evaluation of policies aimed at reducing vesting periods will have to depend on the extent of sophistication attributed to investors.

5 Conclusions

A commonly voiced concern about 401(k)s is that participation among lower income earners is too low given the sizable benefits of contributing. Managers who must meet distribution equity requirements set by ERISA are especially worried about low participation rates among lower income employees. Results from our simulation exercises indicate that lower participation for these individuals may be perfectly consistent with utility maximizing behavior. Indeed, for younger workers especially, there appears to be a strong incentive to wait until the vesting period requirement is satisfied before increasing contributions. To the extent that younger workers represent a larger share of the lower income employees, managers hoping to meet equity laws may have a difficult time persuading these workers to increase 401(k) savings.

The lower participation rate reflects a change in the substitutability between 401(k) plans and conventional savings. In the absence of vesting rules, the generous matching provisions on 401(k) plans induce individuals to save in the plan both for retirement and, more significantly, as a buffer against employment risk. Vesting requirements diminish the attractiveness of the match and consequently reduce the desired contributions for younger workers. Older workers, in contrast, respond to the lower expected value of matching by *increasing* contributions. The net result on aggregate saving is slightly negative for high enough rates of economic growth. The welfare loss associated with longer vesting durations is largest for younger workers with lower education and equals about 4.3 percent of consumption.

The size of the employer matching limit has a strong influence on the quantitative results of the paper. The number of years spent contributing at the limit is higher for lower matching limits. Individuals essentially optimize the amount of employer matches by evening out contributions over time. This effect partly offsets the reduction in participation associated with longer vesting durations.

The analysis in this paper focuses on the saver's problem and assumes that the 401(k) plan features are given exogenously. In reality, the specifics of the 401(k) plan are determined by the interaction between households and firms. For example, firms determine the match rate and vesting duration based on a trade-off between employee attraction and retention. Modeling the firm side of the problem is an important extension to this paper and is the next step in a research agenda aimed at understanding how plan features affect the substitution between 401(k)s and conventional savings.

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6 Appendix

6.1 Additional Tables

Table 11: Contributions, Matching, and Vesting, SCF

	1992	1995	1998
Percent Contributed to 401(k)[a]	14.44	19.51	22.68
Percent Salary Contributed	7.18	6.35	5.68
Average Contribution	4,400	3,639	4,034
Percent with Employer Matching	76.92	83.92	78.88
Average Match Percent	8.19	6.12	5.34
Average Match Amount	3,045	2,849	3,086
Percent Lose Portion with Job Loss	21.18	18.86	14.57
Average Loss if Positive	4,786	4,967	5,914
Percent Loss if Positive	43.97	37.22	33.05

a. All other statistics in this table are conditional on participation.