The Impact of a Roth Option on Outcomes in Employer-Sponsored Savings Plans

John Beshears
Stanford University and NBER

James J. Choi
Yale University and NBER

David Laibson
Harvard University and NBER

Brigitte C. Madrian
Harvard University and NBER

September 12, 2012

Abstract: We estimate the effect of introducing a Roth option to an employer-sponsored savings plan using administrative plan data from nine companies that added a Roth option between 2006 and 2008. We find mixed evidence on whether contribution rates fall after a Roth introduction, which means that the amount of after-tax retirement consumption being purchased by 401(k) contributions may increase. There is suggestive evidence that when choosing the composition of their own contributions, employees contributing above the employer match threshold ignore the fact that matching contributions are entirely before-tax. Conditional on plan participation, Roth participation is highest among young, low-income employees.

Keywords: Roth 401(k)

We thank Scott Weisbenner for helpful comments, and Brendan Price and Luca Maini for excellent research assistance. We acknowledge financial support from the National Institute on Aging (grants R01-AG021650 and P01AG005842) and the Social Security Administration (grant FLR09010202-02 through RAND's Financial Literacy Center and grant #5 RRC08098400-04-00 to the National Bureau of Economic Research as part of the SSA Retirement Research Consortium). The opinions and conclusions expressed are solely those of the authors and do not represent the opinions or policy of NIA, SSA, any agency of the Federal Government, or the NBER. The authors have, at various times in the last three years, been compensated to present academic research at events hosted by financial institutions that administer retirement savings plans. See the authors' websites for a complete list of outside activities.

Since January 1, 2006, U.S. employers have been able to include a Roth contribution option in their 401(k) or 403(b) retirement savings plan. Like contributions to a Roth IRA, employee contributions to a Roth 401(k) or 403(b) are not deductible from current taxable income, but withdrawals of principal, interest, and capital gains in retirement are tax-free. The Plan Sponsor Council of America (2011) reports that 46% of 401(k) plans offered a Roth option in 2010.

In this paper, we examine how the Roth 401(k) affects employee savings choices in the 401(k), focusing on three domains where employee confusion about the Roth is most likely to manifest itself.

First, we estimate how the total dollars contributed to the 401(k) as a fraction of income changes when the Roth is introduced. Choi et al. (2002), Benartzi and Thaler (2007), and Choi et al. (2012) document that many employees seem to choose their 401(k) contribution rate using rules of thumb such as "Contribute the minimum amount necessary to earn the maximum employer match," "Contribute the maximum amount allowed by the plan," or "Contribute 10% of my income." If such rules of thumb dominate decision-making, then the introduction of the Roth will have no effect on total contribution rates. But a dollar of Roth contributions (which is not taxed at withdrawal) buys more retirement consumption than a dollar of before-tax or after-tax contributions (which is taxed at withdrawal) if the marginal tax rate in retirement is positive. Therefore, effective savings would rise when a Roth is introduced as long as contributions to the Roth are not zero and the expected marginal tax rate in retirement is greater than zero.

Second, we measure how the fraction of total contributions allocated to the Roth changes as the total contribution rate increases beyond the employer match threshold (the contribution rate above which additional contributions are not matched). By law, the employer match must be made entirely in before-tax dollars. Choi, Laibson, and Madrian (2009) document that when the employer match's asset allocation is not salient, employees choose the asset allocation of their own contributions without considering the match's asset allocation. If the match's contribution type is also not salient, then employees will distribute their own contributions across contribution types without adjusting for the fact that the employer match is entirely in before-tax dollars. This lack of adjustment will cause, all else equal, the proportion of 401(k) contributions that are in before-tax dollars to be lower—and the proportion in Roth dollars higher—among employees who contribute above the match threshold than among employees who contribute at or below the

match threshold, since the former group has a smaller proportion of their total contributions matched.

Third, we explore what types of employees are most likely to contribute to the Roth, conditional on contributing to the 401(k). Roth contributions are most advantageous to households whose current marginal tax rate is much lower than their marginal tax rate in retirement. If households understand this fact, then we would expect that younger, lower-income employees would be more likely to allocate contributions to the Roth.

We use administrative 401(k) plan data from nine companies that introduced a Roth 401(k) option between 2006 and 2008. We find only mixed evidence that total contribution rates are lower among employees who enroll in the 401(k) after a Roth option is introduced than among employees who enroll before. We also find that among employees who contribute above the match threshold, the proportion of their own contributions allocated to the Roth does not vary with their own contribution rate, which is what would happen if employees ignore the match when making this decision. However, our ability to draw strong conclusions is hampered by the fact that unobserved personal characteristics are correlated with total contribution rates, and it is difficult to estimate how these unobserved characteristics affect the optimal contribution mix. Finally, we find that younger, lower-income employees are more likely to make Roth contributions, which is consistent with employees on the margin responding in a directionally correct manner to the tax incentives created by the Roth.

The remainder of the paper proceeds as follows. In Section I, we summarize some of the institutional rules of the Roth 401(k) and the implications of those rules for optimal savings choices. Section II describes our data. Section III discusses our estimates of the Roth 401(k)'s impact on total 401(k) contribution rates, Section IV examines whether employees overlook the employer match when allocating their own contribution among contribution types, and Section V shows the demographic correlates of Roth participation. Section VI concludes.

I. The rules and economics of the Roth 401(k)

Roth contributions to a 401(k) are not deductible from current-year taxable income, but principal, interest, and capital gains may be withdrawn tax-free if the withdrawal is considered "qualified" because the account has been held for at least five years and the account owner is either older than 59½, disabled, or deceased. Therefore, $1 of pre-tax income can purchase

$(1 - \tau_0)(1 + r)$ of future consumption if a Roth account is used as the savings vehicle and the balance is accessed through a qualified withdrawal, where τ_0 is the household's marginal ordinary income tax rate in the year of the contribution and r is the return earned on the contribution between the contribution and withdrawal dates. Put another way, each dollar contributed to a Roth account buys $1 + r$ of future consumption. The interest and capital gains portion of nonqualified withdrawals are subject to ordinary income tax, and if the account owner is younger than 59½, the withdrawn earnings are also assessed a 10% tax penalty under most circumstances.

In contrast, before-tax 401(k) contributions are deductible from current-year income, but the principal, interest, and capital gains are taxed at the ordinary income tax rate upon withdrawal. Hence, $1 of pre-tax income contributed on a before-tax basis buys $(1 + r)(1 - \tau_1)$ of future consumption, where τ_1 is the household's marginal ordinary income tax rate in the year of the withdrawal. Note that if τ_1 is greater than zero, a dollar in the before-tax account buys less consumption than a dollar in the Roth account because of the difference in tax timing. An additional 10% tax penalty applies to both the principal and earnings withdrawn by account owners younger than 59½.

After-tax 401(k) contributions are not deductible from current taxable income. At withdrawal, principal is not taxed but interest and capital gains are taxed at the ordinary income tax rate. One pre-tax dollar can buy $(1 - \tau_0)[1 + (1 - \tau_1)r]$ of future consumption if an after-tax 401(k) account is used as the savings vehicle. Equivalently, each dollar contributed to an after-tax account buys $1 + (1 - \tau_1)r$ of future consumption. An additional 10% tax penalty applies to earnings that are withdrawn by account owners younger than 59½.

If there are no employer matching contributions in the 401(k), withdrawals occur late enough to be considered qualified by the Roth criteria, and investment earnings are positive, then contributing the next dollar of savings to the Roth is a better financial deal than contributing before-tax if and only if $\tau_0 < \tau_1$. In a progressive tax system, τ_1 will often be less than τ_0 because non-401(k) income in retirement will typically be substantially lower than current income, causing most before-tax 401(k) withdrawal dollars to be taxed at a lower rate than the last dollar of income today. McQuarrie (2008) uses this observation to argue that the Roth 401(k) is inferior to a before-tax 401(k) for many households whose current income pushes them above the lowest marginal tax bracket.

The relative appeal of the Roth increases with the probability of withdrawal before age 59½, since Roth principal is exempt from the 10% early withdrawal penalty but before-tax principal is not. Roth contributions are always a better deal than after-tax contributions if the money is held in the 401(k) long enough to meet the Roth qualifying withdrawal criteria and investment earnings are positive. However, after-tax contributions are sometimes more liquid before age 59½, since some 401(k) plans allow younger employees to make withdrawals from after-tax balances while still employed by the company without demonstrating financial hardship.

Employer matching contributions must always be made using before-tax dollars, meaning that the entire principal and earnings of the match balance are subject to ordinary income tax upon withdrawal. A company may not match certain types of employee contributions (e.g., after-tax contributions), but among the types it does match, the match formula typically does not vary by the type of contribution. This invariance reduces the attractiveness of Roth and after-tax contributions if the employee's marginal 401(k) contribution dollar is being matched. Let m be the rate at which employee contributions are matched. One pre-tax dollar can buy m match dollars if it is saved using a before-tax account, but only $(1 - \tau_0)m$ match dollars if it saved using a Roth or after-tax account. The condition under which employees who have no probability of making a non-qualified withdrawal are better off contributing to the Roth rather than the before-tax account is now more restrictive: if and only if

$$(1 - \tau_0)[1 + m(1 - \tau_1)] > (1 - \tau_1)(1 + m). \quad (1)$$

Despite the Roth's disadvantaged position with respect to the match, it is still the case that one needs to contribute less than $1 to the Roth in order to buy as much retirement consumption (including what the match would fund) as one would get from contributing $1 before-tax and earning the match, provided the marginal tax rate in retirement is greater than zero.[1]

The combined before-tax plus Roth contributions in a calendar year cannot exceed a certain amount that is adjusted each year. For people younger than 50, this limit was $14,000 in 2005 (when Roth contributions were not allowed), $15,000 in 2006, $15,500 from 2007 to 2008, and $16,500 from 2009 to 2011. People age 50 and older could contribute an additional $4,000 in 2005, $5,000 from 2006 to 2008, and $5,500 from 2009 to 2011. All employee plus employer contributions to the 401(k) in a calendar year could not exceed $42,000 in 2005, $44,000 in

[1] Specifically, one needs to contribute $[(1 - \tau_1) + m(1 - \tau_1)]/[1 + m(1 - \tau_1)]$ dollars, which is less than 1 if $\tau_1 > 0$.

2006, $45,000 in 2007, $46,000 in 2008, and $49,000 from 2009 to 2011. Because a dollar of Roth balances buys weakly more retirement consumption than a dollar of before-tax balances, people who are constrained by the before-tax plus Roth contribution ceiling could find it advantageous to make Roth contributions instead of before-tax contributions in order to extend the 401(k) tax shelter over more effective dollars.

II. Data description

Our 401(k) administrative data come from Aon Hewitt, a large U.S. benefits administration and consulting firm. We selected nine companies that introduced a Roth option to their 401(k) plan and for which we have enough data to observe employee choices up to one year before and one year after the introduction. The data are repeated cross-sectional snapshots of all employees at each calendar-year-end. Each snapshot contains individual-level data on every employee's current plan participation status, plan enrollment date, monthly contribution rates[2], birth date, hire date, salary, age, and gender.

Table 1 shows the characteristics of each company as of year-end 2009, the most recent year where we have data for all nine companies. In order to preserve these companies' anonymity, we refer to each company by the letters A through I and only disclose approximate employee counts. Seven of the nine companies are in the financial services industry, and both average and median salaries are typically very high, breaking into the six-figure range for Companies A, E, F, and I. Average age ranges from 36 to 47 years, average tenure at the company from five years to thirteen years, and male percentage from 33% to 62%.

Table 2 presents relevant features of the 401(k) plan at each company. Six companies introduced the Roth option in 2006, and the remaining three introduced the Roth on January 1, 2008. Companies A, B, and C automatically enroll their employees at a 3% before-tax contribution rate unless they opt out, which results in 401(k) participation rates of 93%.

[2] Month-end contribution rates are missing from January to March 2006 for Company D, January to April 2006 and June 2006 for Company G, January to August 2008 for Company C, and from December 2005 to March 2006 for employees who enrolled between December 13, 2005 and March 31, 2006 at Company I. We assign the first observed contribution rate after the missing period to prior missing month-ends unless the employee was not enrolled in the 401(k) at that month-end, in which case we assign a 0% contribution rate. For December 13 to December 31, 2005 enrollees at Company I, we do not impute values for their missing December 2005 contribution rates because the Roth option was not available at that time, whereas these employees' first contribution rate observations come at a time when the Roth was available. It is unclear what December 2005 contribution rates we should impute for Company I employees who had a positive Roth contribution rate in April 2006.

Companies D through I by default do not enroll employees in the 401(k), and their 401(k) participation rates are correspondingly lower, ranging from 62% to 85%. Six companies match employee contributions at rates between 70% and 133%, most commonly on the first 6% of income contributed.

III. The Roth 401(k)'s impact on total 401(k) contribution rates

A. Hire cohort analysis

Our first approach to estimating the impact of the Roth 401(k) on total contribution rates (before-tax plus after-tax plus Roth, if available) compares employees hired in the twelfth month prior to the introduction of the Roth to employees hired in the month immediately following the introduction of the Roth. The advantage of this approach is that employee decisions on when to join a company are probably unrelated to whether the company offers a Roth 401(k), so whether one is exposed to the Roth early in one's tenure is plausibly exogenous. The disadvantage is that the two comparison groups are separated by a year, so differences between the two groups could be driven by time-specific shocks (e.g. macroeconomic events). Our second estimation approach, discussed in Section III.B, does a better job of addressing the time shock concern at the expense of possibly introducing endogeneity in the selection into comparison groups.

Table 3 shows the average age at hire, salary in the hire year, and gender composition of the before and after hire cohorts at each company. Companies G and H do not have salary data available. Five companies—B, C, E, G, and H—experienced no statistically significant changes in their observed variables. The other four companies experienced at least one statistically significant change across cohorts. We will control for age, salary (when possible), and gender in the regressions that follow, but it is possible that companies in which observed characteristics change across cohorts are more likely to have unobserved characteristics change across cohorts as well. We will therefore examine effects averaged both across all companies and across the subset of companies where no observable characteristics changed significantly.

Figure 1 plots the average total contribution rate of each hire cohort against tenure at the company through eleven months (the maximum tenure the pre-Roth cohort achieves before the Roth was introduced), pooling all nine companies together. The post-Roth cohort begins with a lower average contribution rate than the pre-Roth cohort, but from the fourth month of tenure onwards, the post-Roth cohort has a higher contribution rate than the pre-Roth cohort. Table 4

shows the average contribution rate comparisons separately for each company at six and eleven months after hire. The only difference that is statistically significant is at Company B at six months, where the post-Roth cohort contributes 1.9% of income more than the pre-Roth cohort. Pooling together all nine companies yields an insignificant average contribution increase at six or eleven months of 0.2% of income. Dropping the four companies with significant observable changes in employee characteristics across hire cohorts yields an insignificant average contribution decrease of 0.04% to 0.08% of income over the same time horizons.

In Table 5, we regress total contribution rates at six or eleven months of tenure on a post-Roth hire cohort dummy, age, age squared, gender, and log salary. None of the companies' post-Roth hire cohort dummies are individually significant at six months, and only Company H's post-Roth dummy is significant (–0.5% of income) at eleven months. Pooling together all seven companies with complete employee data and controlling for company dummies yields an insignificant total contribution rate increase in the post-Roth cohort of 0.3% of income at both six and eleven months of tenure. Excluding companies with significant observable employee characteristic changes yields an insignificant total contribution rate increase of 0.2% at six months and 0.7% at eleven months.

This analysis indicates that the Roth 401(k) did not change total contributions to the 401(k); if anything, contribution rates somewhat increased. An unchanged total contribution rate translates into more after-tax retirement dollars if some of those contributions are directed to the Roth and the balances are kept in the Roth for long enough. However, an unchanged total contribution rate could also be due to Roth participation being minimal. Figures 2A and 2B show how the estimated Roth introduction effect at each company correlates with the percent of the company's post-Roth cohort that has a positive Roth contribution rate at six or eleven months after hire. Between 2% and 15% of employees in the post-Roth cohorts have a positive Roth contribution rate at six months, and that range grows slightly to between 2% and 16% at eleven months. The fitted regression lines indicate that there is a small negative association between the estimated treatment effect and Roth participation rates at six months after hire (slope = –1.32, t = –0.14), but a small positive association at eleven months (slope = 2.32, t = 0.41). At both time horizons, the two companies with the highest Roth participation rates—Companies C and D—have positive estimated Roth introduction treatment effects. Overall, there is little indication that our null Roth introduction effects are due to limited participation in the Roth.

B. Enrollment cohort analysis

Our second approach to estimating the Roth's impact on total 401(k) contribution rates compares the total contribution rate chosen by employees who enrolled just before the Roth's introduction to that chosen by employees who enrolled just after the Roth introduction. Because we identify the Roth effect using the discontinuity in contribution choices around the Roth introduction date, unobserved time shocks that evolve smoothly around the introduction date should not contaminate our estimates. The primary drawback of this methodology is that employees choose their own enrollment date, and at least some knew when the Roth would be introduced, so the propensity to delay enrollment until just after the Roth introduction date might be correlated with one's savings preferences.

Table 6 compares the age at 401(k) enrollment, gender composition, salary in enrollment year, and tenure at each company of the employees who enrolled in the 401(k) during the month prior to the Roth introduction and the employees who enrolled during the month following the Roth introduction. The columns labeled "Discontinuity" reports the coefficient ρ and its standard error from the regression

$$y_i = \alpha + \beta \times (t_i - t_0) + \gamma \times (t_i - t_0) \times \textit{Post-Roth}_i + \rho \times \textit{Post-Roth}_i + \varepsilon_i, \quad (2)$$

where y_i is the age, male dummy, salary, or tenure of employee i, $t_i - t_0$ is the number of days between the employee's enrollment date and the Roth introduction date, $\textit{Post-Roth}_i$ is a dummy for whether the employee enrolled after the Roth introduction date, and ε_i is the residual term. The coefficient ρ measures whether there is a jump in y after controlling for a pre-introduction time trend and a post-introduction time trend of different slopes. The regression sample includes employees who enrolled in the six months prior to and the six months after the Roth introduction.

There is no significant jump in average age, gender composition, salary, and tenure around the Roth introduction at Companies A, C, E, and I. As in the hire-cohort analysis, we will control for observable employee characteristics in our contribution rate regressions, but we will also examine whether our results change if we restrict our sample to companies where there were no significant jumps in observable employee characteristics.

Table 7 shows the average total contribution rate chosen upon enrollment at each company among employees who enrolled in the 401(k) in the month before Roth introduction

and in the month after Roth introduction. None of the differences are significant except at company I, where the average total contribution rate falls by 3.9% of income. Pooling together all the companies yields a significant 1.2% drop in the average total contribution rate, and excluding companies with at least one discontinuity in enrollee characteristics results in a still-significant 1.0% drop in the average total contribution rate.

In Table 8, we control for contribution rate trends, as in equation (2), and additionally control for age, age squared, gender, log salary, and log tenure. We still estimate a significant 2.0% of income decrease in the average contribution rate at Company I, but it is counterbalanced by a significant 1.4% of income increase at Company H. When we pool all the companies with complete employee characteristic data (including company dummies and allowing for the pre- and post-Roth trends to differ at each company), the –1.0% discontinuity around the Roth introduction is significant only at the 10% level, and the discontinuity remains significant at the 10% level if we drop companies where there was a significant discontinuity in enrollee characteristics.

In Figure 3, we examine how the Roth introduction effect estimated at each company correlates with the average percent of the post-Roth enrollment cohort's contributions going to the Roth.[3] We see stronger evidence than in the hire cohort analysis that the Roth introduction effect is more negative when the Roth is more popular after its introduction. The slope of the fitted line is –10.84—meaning a 10 percentage point increase in the proportion of Roth contributions is associated with a 1.08% of income decrease in total contributions—with a *t*-statistic of –2.25, corresponding to a *p*-value of 0.059.[4] Therefore, the lack of a more significant overall Roth introduction effect in the enrollment cohort analysis may be due to insufficiently widespread usage of the Roth.

IV. Do employees overlook the employer match when deciding among before-tax, after-tax, and Roth contributions?

As discussed in Section I, all employer matching contributions must be made in before-tax dollars. Suppose an employee is ignorant of this fact and allocates a proportion *p* of her own

[3] In the hire cohort analysis, we did not compare the Roth introduction effect to the average percent of the post-Roth hire cohort's contributions going to the Roth because it is unclear what value should be assigned to those who are contributing nothing to the 401(k).

[4] The small number of degrees of freedom in this regression causes the normal distribution to not be a good approximation for the *t* distribution, which is why this *t*-statistic corresponds to a *p*-value above 0.05.

contributions to the Roth because she wants a proportion p of her *entire* employee plus matching 401(k) contribution to be in the Roth. The employer matches employee contributions up to h fraction of income at the rate m. Then if the employee's contribution rate c is less than or equal to h, the percent of employee plus match contributions that goes to the Roth is $p/(1 + m)$. If the employee contributes more than h, the Roth percentage is $pc/(mh + c)$. In order to ensure that a proportion p of the employee plus match contribution is actually in the Roth, the employee should allocate a proportion $p^* = p(1 + m)$ of her own contribution to the Roth if $c \leq h$, and a proportion $p^* = p(mh + c)/c$ of her own contributions to the Roth if $c > h$.

Figure 4 plots the fraction p^* of employee contributions that should go to the Roth as a function of the total employee contribution rate for the case where $p = 0.5$, $h = 0.05$, and $m = 1$. The fraction is flat to the left of the match threshold h. It then falls to the right of h because contributions above h do not garner before-tax matching contributions, so the employee should decrease the fraction of his own contributions going to the Roth (and increase the fraction going to before-tax contributions) to compensate.

We test how the fraction of employee contributions allocated to the Roth changes with the total employee contribution rate at each of the six companies with a match, selecting all employees who enrolled in the 401(k) during the first two full calendar years after the Roth was introduced.[5] The dependent variable is the fraction of the total employee contribution rate that goes to the Roth in the first pay period where the employee earns a match.[6] The explanatory variables are the total employee contribution rate, a dummy for the total employee contribution rate being above the match threshold, the interaction of these two variables, age, age squared, gender, log salary in the calendar year of enrollment, and log tenure at enrollment.

Table 9 shows a remarkable regularity: At all six companies, the coefficient on the interaction between total employee contribution rate and a dummy for being above the match threshold is almost exactly equal to the negative of the coefficient on the total employee contribution rate. This means that beyond the match threshold, the proportion of employee contributions allocated to the Roth is virtually flat with respect to the total employee contribution rate, causing the proportion of employee plus match contributions going to the Roth to be

[5] That is, we include January 2007 to December 2008 enrollees for Companies B and F, which introduced the Roth mid-year.

[6] Companies A, D, and F do not match contributions until the employee has attained one year of tenure. At these companies, we use the first recorded contribution rate after one year of tenure.

increasing with the total employee contribution rate. This behavior appears to be inconsistent with employees adjusting their own contribution allocations in response to the phase-out of the match. However, below the match threshold, there is no stable relationship between the fraction of employee contributions allocated to the Roth and the total employee contribution rate; the correlation is significantly positive at three companies, significantly negative at one, and insignificant at two. This generally non-zero relationship below the match threshold highlights the possibility that optimal allocations to the Roth could be correlated with unobserved employee characteristics that are themselves correlated with the total employee contribution rate. Since we do not directly observe optimal allocations to the Roth, we must be cautious in interpreting the fact that allocations of employee contributions to the Roth are not responsive to the total employee contribution rate above the match threshold.

V. Which employees participate in the Roth 401(k)?

In this section, we examine how Roth participation varies with age and income. Section I showed that in order for a Roth contribution to be financially advantageous, the before-tax dollar devoted to funding the Roth contribution must be taxed at a lower rate today than that before-tax dollar would be taxed upon withdrawal if it funded a before-tax contribution instead. The people for whom this condition is most likely to hold are young and lower-income individuals. The young are more likely to have higher income in retirement than they do currently. Another factor increasing optimal Roth participation for the young is that the young have a greater probability than the middle-aged of making a 401(k) withdrawal sometime before the age of 59½, and Roth withdrawals are penalized less severely than before-tax withdrawals. Lower-income individuals are more likely to be among the 47% of tax units that have no current income tax liability (Williams, 2009), so their marginal tax rate in retirement is very likely to be weakly greater than it is today.

Figure 5 plots, by age and salary range, the fraction of 2009 enrollees across all nine companies (which had all introduced the Roth before 2009) who contributed a positive amount to the Roth during 2009. Roth participation declines with age in all salary groups, consistent with employees on the margin responding in a directionally optimal fashion to the Roth tax incentives. Roth participation also generally declines with income, but there is one large exception: employees in their 20s who make $20,000 to $40,000 are 14 percentage points *less*

likely to participate in the Roth than employees of the same age group who make between $40,000 and $60,000. This difference might be due to young employees who make between $40,000 and $60,000 being more likely to be white-collar professionals who will experience high wage growth (and hence tax bracket growth). However, employees in their 20s who make less than $20,000 are also 10 percentage points more likely to participate in the Roth than employees in their 20s who make between $20,000 to $40,000.

VI. Conclusion

We have examined the impact of introducing a Roth 401(k) option on total 401(k) contribution rates, how the fraction of employee contributions allocated to the Roth 401(k) varies with how much of the employee contribution is matched by the employer, and what kinds of employees contribute to the Roth.

We find mixed evidence on whether introducing a Roth option lowers total contribution rates. Comparing contribution rates of employees hired one year prior to the Roth introduction to employees hired immediately after the Roth introduction yields no significant evidence of a Roth effect on total contribution rates, which means that the total amount of retirement consumption being purchased via the 401(k) increases. Comparing contribution rates of employees who enrolled in the month prior to the Roth introduction to employees who enrolled in the month after the Roth introduction yields evidence of a 1% of income contribution rate decrease, but this is significant only at the 10% level once we control for employee characteristics and time trends.

The absence of a drop in total contribution rates after a Roth introduction would be consistent with employees choosing 401(k) contribution rates without adjusting for the different tax treatment of Roth balances. However, we would not be able to rule out the possibilities that total contribution rates did not drop because employees substituted Roth 401(k) contributions for Roth IRA contributions, or because the substitution effect generated by the expansion of the 401(k) investment opportunity set caused employees to save more. The typical employee at our sample firms is also unusually well-paid, so many employees are constrained by the before-tax plus Roth annual dollar contribution limit. Right-censoring of total contribution rates could obscure drops in the latent desired total contribution rate.[7] The dollar contribution limit could

[7] In principle, censoring could be handled by a tobit estimator. However, it is not always clear which observations should be treated as censored. For example, an employee enrolling in December 2006 is almost never facing a

also cause chosen contribution rates to paint a misleading picture of annual dollar savings flows; a 40-year-old with a $200,000 salary would end up contributing $16,500 in 2011 whether she chose a 10% Roth contribution rate or a 20% Roth contribution rate because the contribution limit is binding for her at both contribution rates. Finally, the lack of responsiveness of total contributions to the Roth may be due to the low rate of Roth adoption.

We find that the fraction of total employee contributions allocated to the Roth does not vary with the total employee contribution rate above the match threshold. As a result, the fraction of employee plus match contributions allocated to the Roth increases with the total employee contribution rate above the match threshold, since matching contributions are made entirely in before-tax dollars. This behavior could be consistent with employees ignoring the match contribution's allocations when making choices about how to allocate their own contributions.

Finally, we find that young, low-income employees are the most likely to participate in the Roth. Since the marginal tax rate on future 401(k) withdrawals must be lower than the current marginal ordinary income tax rate in order for Roth contributions to be more attractive than before-tax 401(k) contributions, this pattern is directionally consistent with optimal behavior.

References

Benartzi, Shlomo, and Richard H. Thaler, 2007. "Heuristics and biases in retirement savings behavior." *Journal of Economic Perspectives* 21, pp. 81-104.

Choi, James J., Emily Haisley, Jennifer Kurkoski, and Cade Massey, 2012. "Small Cues Change Savings Choices." NBER Working Paper 17843.

Choi, James J., David Laibson, Brigitte C. Madrian, 2009. "Mental Accounting in Portfolio Choice: Evidence from a Flypaper Effect." *American Economic Review* 99, pp. 2085-2095.

Choi, James J., David Laibson, Brigitte C. Madrian, and Andrew Metrick, 2002. "Defined Contribution Pensions: Plan Rules, Participant Decisions, and the Path of Least Resistance." In James Poterba, ed., *Tax Policy and the Economy* 16, pp. 67-114.

McQuarrie, Edward F., 2008. "Thinking About a Roth 401(k)? Think Again." *Journal of Financial Planning* (July), pp. 38-48.

---

binding constraint on his 2006 dollar contributions, so his contribution rate is technically uncensored. However, he may choose his contribution rate so that he will not exceed the 2007 dollar contribution limit if he leaves the contribution rate unchanged, so his December 2006 contribution rate is *de facto* censored.

Plan Sponsor Council of America, 2011. "PSCA Releases 54th Annual Survey of Profit Sharing and 401(k) Plans." Press release. October 11. http://www.psca.org/LinkClick.aspx?fileticket=E35rrQGu9iQ%3d&tabid=36 (accessed November 28, 2011).

Williams, Roberton, 2009. "Who Pays No Income Tax?" Washington D.C.: Tax Policy Center, Urban Institute and Brookings Institution.

Table 1. Company characteristics as of 2009

Company	Industry	Total employees	Average age	Median salary	Average salary	Average tenure	Percent male
A	Pharmaceutical	~ 40,000	42.6	$95,100	$105,885	10.1 years	53%
B	Insurance	~ 5,000	45.9	$77,079	$84,285	11.4 years	42%
C	Banking	~ 20,000	44.3	$75,000	$86,634	12.9 years	54%
D	Insurance	~ 30,000	43.2	$56,124	$75,940	9.1 years	46%
E	Financial services	~ 20,000	35.7	$136,900	$283,466	5.1 years	61%
F	Financial services	~ 20,000	43.5	$82,656	$150,827	7.8 years	60%
G	Financial services	~ 10,000	47.0	N/A	N/A	11.7 years	53%
H	Banking	~ 30,000	40.2	N/A	N/A	8.4 years	33%
I	Business services	~ 30,000	35.9	$83,800	$109,764	6.1 years	62%

Table 2. 401(k) characteristics as of 2009

Company	Participation rate	Enrollment default	Employer match structure	Max contribution allowed (% of salary)	Roth 401(k) introduction date
A	93%	Auto-enrollment, 3% before-tax contribution rate	75% match on first 6% of income contributed after 1 year of tenure	50%	1/1/2008
B	93%	Auto-enrollment, 3% before-tax contribution rate	70% match on first 6% of income contributed	20%	9/1/2006
C	93%	Auto-enrollment, 3% before-tax contribution rate	100% match on first 6% of income contributed. Employees with < 5 years of tenure matched at 80%	100%	1/1/2008
D	76%	Non-enrollment	133% match on first 3% of income contributed after 1 year of tenure	45%	1/1/2006
E	62%	Non-enrollment	No match	50%	2/1/2006
F	69%	Non-enrollment	100% match on first 6% of income contributed after 1 year of tenure	None	12/18/2006
G	80%	Non-enrollment	No match		1/1/2006
H	67%	Non-enrollment	115% match on first 6% of income contributed	20%	1/1/2008
I	85%	Non-enrollment	No match	50%	1/1/2006

Table 3. Comparison of hire cohort characteristics

This table shows the average age as of hire date, average salary in the hire year, and gender composition at each company among employees who were hired in the twelfth month prior to Roth introduction or in the month after Roth introduction. The change in these variables between the before and after cohorts is also reported, with standard errors in parentheses. Salary is in 2005 dollars, deflated by CPI-W. The last column shows the number of employees in the before and after cohorts combined. Average salary is calculated using fewer employees than in the last column because of missing data.

	Age			Salary			Percent male			
Company	Before Roth	After Roth	Change	Before Roth	After Roth	Change	Before Roth	After Roth	Change	*N*
A	35.7	33.5	-2.17**	$82,450	$64,422	-18,028**	47.1%	46.1%	-1.03	753
			(0.69)			(3,375)			(3.64)	
B	36.2	37.8	1.67	$62,745	$72,698	9,953	39.5%	52.3%	12.74	130
			(1.97)			(7,800)			(9.20)	
C	34.9	35.3	0.39	$55,200	$57,715	2,515	58.9%	64.1%	5.22	317
			(1.19)			(3,932)			(5.51)	
D	35.6	37.6	1.99**	$38,504	$41,167	2,663	56.4%	48.1%	-8.23*	870
			(0.73)			(2,735)			(3.38)	
E	31.6	30.0	-1.58	$173,095	$159,704	-13,391	60.6%	67.8%	7.25	219
			(0.97)			(31,154)			(6.49)	
F	34.1	34.8	0.76	$51,170	$62,255	11,085*	55.4%	56.6%	1.19	593
			(0.94)			(5,346)			(4.09)	
G	37.9	35.9	-2.06	N/A	N/A	N/A	46.4%	48.2%	-1.80	438
			(1.21)						(4.80)	
H	33.3	32.6	-0.72	N/A	N/A	N/A	38.3%	40.1%	2.78	1,313
			(0.61)						(2.70)	
I	34.8	33.7	-1.14	$66,483	$77,838	11,355**	58.5%	59.4%	0.90	1,075
			(0.66)			(3,475)			(3.14)	

* Significant at 5% level. ** Significant at 1% level.

Table 4. Hire cohort average total contribution rates

This table shows the average total employee contribution rate (before-tax plus Roth plus after-tax) at six or eleven months after hire among employees who were hired in the twelfth month prior to Roth introduction or in the month after Roth introduction. The change in the average total contribution rate between the before and after cohorts is also reported, with standard errors in parentheses. The penultimate row shows the averages pooling all companies together, and the last row shows the averages excluding companies that had one or more significant demographic changes across the before and after hire cohorts in Table 3.

	Total contribution rate 6 months after hire			Total contribution rate 11 months after hire		
Company	Before Roth	After Roth	Change	Before Roth	After Roth	Change
A	6.28%	5.64%	-0.64	6.31%	5.74%	-0.57
			(0.42)			(0.46)
B	4.88%	6.82%	1.93*	4.59%	5.71%	1.11
			(0.90)			(0.91)
C	5.55%	6.53%	0.97	5.42%	6.54%	1.12
			(0.85)			(0.78)
D	2.75%	3.14%	0.39	2.82%	3.39%	0.57
			(0.35)			(0.36)
E	7.89%	5.97%	-1.92	7.23%	7.70%	0.47
			(1.35)			(1.52)
F	4.81%	6.36%	1.55	6.49%	7.44%	0.95
			(1.04)			(1.4)
G	4.17%	3.75%	-0.42	4.38%	3.79%	0.58
			(0.74)			(0.77)
H	1.47%	1.35%	-0.12	1.95%	1.40%	-0.55
			(0.20)			(0.21)
I	4.72%	5.19%	0.47	4.95%	5.42%	0.48
			(0.46)			(0.48)
All	4.01%	4.20%	0.20	4.32%	4.49%	0.17
			(0.19)			(0.22)
All with no demographic changes	3.22%	3.17%	-0.04	3.43%	3.35%	-0.08
			(0.26)			(0.27)

* Significant at 5% level. ** Significant at 1% level.

Table 5. Hire cohort regression

Each row is a regression where the dependent variable is the total employee contribution rate (before-tax plus Roth plus after-tax) at six months after hire (Panel A) or eleven months after hire (Panel B). The sample is employees who were hired in the twelfth month prior to Roth introduction or in the month after Roth introduction at the company indicated in the first column. The penultimate row in each panel includes in its sample all companies that have a complete set of employee characteristic data. The last row in each panel includes all companies that have a complete set of employee characteristic data and did not have a significant demographic change across the before and after hire cohorts in Table 3. The explanatory variables are a constant, a dummy for being in the post-Roth hire cohort, age as of hire date, age squared, a male dummy, and log salary in the year of hire (in 2005 dollars).

Panel A: Contribution rate 6 months after hire

Company	Roth	Age	Age^2	Male	log(Salary)	N[a]
A	-0.14	-0.05	0.003	0.39	1.94**	521
	(0.48)	(0.22)	(0.003)	(0.47)	(0.59)	
B	1.40	-0.35	0.005	0.36	3.11**	123
	(0.84)	(0.30)	(0.004)	(0.90)	(0.94)	
C	0.84	-0.19	0.004	-1.40	2.06*	274
	(0.92)	(0.33)	(0.004)	(0.95)	(1.03)	
D	0.38	0.32**	-0.004*	0.20	1.52**	853
	(0.35)	(0.12)	(0.002)	(0.35)	(0.21)	
E	-1.46	-0.29	0.008	-0.35	-0.18	198
	(1.47)	(0.89)	(0.01)	(1.54)	(1.24)	
F	1.12	0.41	-0.002	-0.40	0.47	572
	(1.06)	(0.34)	(0.004)	(1.08)	(0.57)	
G	-0.06	0.54**	-0.005*	1.38	N/A	437
	(0.72)	(0.18)	(0.002)	(0.71)		
H	-0.09	0.24**	-0.002**	0.75**	N/A	1,313
	(0.20)	(0.06)	(0.0008)	(0.20)		
I	0.22	-0.66**	0.009**	-0.54	4.38**	887
	(0.52)	(0.17)	(0.002)	(0.53)	(0.65)	
All with complete data	0.29	-0.006	0.001	-0.07	1.64**	3,428
	(0.27)	(0.10)	(0.001)	(0.28)	(0.20)	
Complete data, no demographic changes	0.21	-0.12	0.003	-0.57	1.43*	595
	(0.67)	(0.26)	(0.003)	(0.68)	(0.65)	

[a] The numbers here do not usually correspond to the whole sample reported in Table 3. This is because of partial missing data, usually salary.

Panel B: Contribution rate 11 months after hire						
Company	Roth	Age	Age^2	Male	log(Salary)	N
A	-0.64	0.11	-0.0008	0.90	1.58*	521
	(0.55)	(0.25)	(0.003)	(0.54)	(0.67)	
B	0.77	-0.10	0.002	-0.21	2.47*	123
	(0.92)	(0.32)	(0.004)	(0.98)	(1.02)	
C	0.80	-0.52	0.008*	-0.99	2.37*	274
	(0.82)	(0.30)	(0.004)	(0.85)	(0.92)	
D	0.50	0.26*	-0.003	0.12	0.66**	853
	(0.36)	(0.12)	(0.002)	(0.36)	(0.22)	
E	0.56	-0.80	0.02	-0.44	0.74	198
	(1.65)	(1.00)	(0.01)	(1.74)	(1.40)	
F	0.37	0.64	-0.005	-0.37	0.76	572
	(1.44)	(0.47)	(0.006)	(1.47)	(0.77)	
G	-0.21	0.45*	-0.004	0.93	N/A	437
	(0.75)	(0.18)	(0.002)	(0.75)		
H	-0.53*	0.19**	-0.002*	0.93**	N/A	1,313
	(0.21)	(0.063)	(0.0008)	(0.21)		
I	0.45	-0.57**	0.008**	-0.08	4.36**	887
	(0.55)	(0.17)	(0.002)	(0.56)	(0.68)	
All with complete data	0.31	0.07	0.0004	0.16	1.51**	3,428
	(0.33)	(0.11)	(0.001)	(0.33)	(0.24)	
Complete data, no demographic changes	0.67	-0.29	0.005	-0.57	1.75**	595
	(0.69)	(0.27)	(0.004)	(0.71)	(0.67)	

* Significant at 5% level. ** Significant at 1% level.

Table 6. Demographic discontinuities at Roth introduction

This table shows the average age at 401(k) enrollment, average salary in the calendar year of Roth introduction, gender composition, and average tenure upon 401(k) enrollment at each company among employees who enrolled in the 401(k) in the month prior to Roth introduction or in the month following Roth introduction. The difference in these variables that cannot be accounted for by pre-Roth and post-Roth trends, as estimated in regression equation (2), is reported in the "Discontinuity" columns, with standard errors in parentheses. The last column shows the number of employees in the before and after cohorts combined. The salary figures are computed using fewer employees than in the last column because of missing data.

	Age			Percent male			Salary			Tenure			
Com-pany	Before Roth	After Roth	Discon-tinuity	Before Roth	After Roth	Discon-tinuity	Before Roth	After Roth	Discon-tinuity	Before Roth	After Roth	Discon-tinuity	N
A	36.0	35.4	0.22	44.4	48.3	-3.23	84,963	81,850	-834	2.02	2.18	0.28	568
			(0.78)			(3.46)			(4,027)			(0.36)	
B	38.7	38.3	5.26**	46.9	45.8	-5.63	66,851	69,216	973	1.91	1.17	0.39	160
			(2.01)			(6.81)			(6,236)			(0.72)	
C	37.0	35.5	-0.24	57.0	60.4	2.33	67,019	63,244	2,500	0.93	1.84	0.54	247
			(0.99)			(4.94)			(4,063)			(0.41)	
D	41.1	38.0	-0.49	55.0	45.1	-9.14**	81,297	53,021	-6,272	4.94	3.10	0.78	937
			(0.86)			(2.53)			(5,702)			(0.73)	
E	31.2	31.7	-0.60	59.4	51.6	-1.97	207,488	182,908	-4,563	1.48	1.09	0.06	220
			(0.81)			(5.11)			(24,906)			(0.24)	
F	37.5	39.7	4.36**	61.5	61.0	0.21	110,021	150,384	52,734**	0.84	1.24	0.19	650
			(0.83)			(3.45)			(12,197)			(0.17)	
G	40.5	36.2	-1.06	57.1	51.1	-8.59	N/A	N/A	N/A	1.26	2.31	1.18**	213
			(1.27)			(4.81)						(0.34)	
H	35.4	40.1	5.16**	37.0	23.8	-17.6**	N/A	N/A	N/A	1.30	7.14	6.00**	1,499
			(0.87)			(3.20)						(0.89)	
I	32.3	32.6	0.93	55.8	56.9	-4.38	80,725	79,224	1,863	0.65	1.62	0.30	366
			(0.79)			(3.59)			(4,622)			(0.24)	

* Significant at 5% level. ** Significant at 1% level.

Table 7. Participation cohort average total contribution rates

This table shows the average total employee contribution rate (before-tax plus Roth plus after-tax) chosen upon enrollment by employees who enrolled in the 401(k) in the month prior to Roth introduction or in the month following Roth introduction. The change in the average total contribution rate between the before and after cohorts is also reported, with standard errors in parentheses. The penultimate row shows the averages pooling all companies together, and the last row shows the averages excluding companies that had one or more significant demographic changes across the before and after hire cohorts in Table 6.

Company	Enrolled in month before Roth introduction	Enrolled in month after Roth introduction	Change
A	7.17%	7.32%	0.15
			(0.53)
B	6.11%	5.64%	-0.47
			(0.77)
C	7.32%	7.73%	0.41
			(1.36)
D	8.58%	7.86%	-0.71
			(0.48)
E	12.34%	11.98%	-0.36
			(1.58)
F	18.35%	18.91%	0.56
			(2.22)
G	8.86%	8.68%	-0.18
			(1.21)
H	6.49%	7.27%	0.78
			(0.42)
I[2]	12.21%	8.34%	-3.86**
			(1.02)
All	10.18%	8.95%	-1.23**
			(0.38)
All with no demographic discontinuity	9.27%	8.25%	-1.02*
			(0.49)

* Significant at 5% level. ** Significant at 1% level.

[2] We only have data up to the 13th of the month before Roth introduction for this company.

Table 8. Participation cohort regression estimates of Roth introduction's effect on total contribution rates

Each row shows results from a separate regression where the dependent variable is the total employee contribution rate (before-tax plus Roth plus after-tax) chosen upon 401(k) enrollment. The sample is employees who enrolled during the six months prior to or the six months following the Roth introduction at the company indicated in the first column. The penultimate row includes in its sample all companies that have a complete set of employee characteristic data. The last row includes all companies that have a complete set of employee characteristic data and did not have a significant demographic change across the before and after enrollment cohorts in Table 6. The explanatory variables are a constant, a dummy for being in the post-Roth enrollment cohort, age as of enrollment date, age squared, a male dummy, log salary in the calendar year of Roth introduction, a time trend, and the time trend interacted with the post-Roth dummy. In the last two rows, the time trends are allowed to vary by company, and we control for company fixed effects as well. Standard errors are in parentheses below coefficient estimates.

Company	Roth	Age	Age^2	Male	log(Salary)	log(Tenure)	Trend	Post-Roth Δtrend	N
A	-0.29	-0.21*	0.003*	0.20	2.59**	-0.22**	0.0009	-0.003	3,221
	(0.73)	(0.10)	(0.001)	(0.21)	(0.27)	(0.05)	(0.005)	(0.007)	
B	0.43	0.06	0.0004	0.35	0.80**	-0.36**	-0.003	0.001	726
	(0.89)	(0.12)	(0.002)	(0.34)	(0.22)	(0.10)	(0.006)	(0.008)	
C	-0.73	-0.50	0.007	0.66	3.11**	-0.38**	-0.0006	0.009	1,562
	(1.23)	(0.34)	(0.005)	(0.47)	(0.51)	(0.13)	(0.008)	(-0.01)	
D	-0.14	0.08	0.0004	0.43*	0.94**	-0.16**	0.004	-0.002	4,788
	(0.40)	(0.07)	(0.0009)	(0.20)	(0.16)	(0.05)	(0.002)	(0.004)	
E	0.14	-0.47	0.007	0.93	3.64**	0.24	-0.003	0.01	1,607
	(1.43)	(0.36)	(0.005)	(0.71)	(0.66)	(0.16)	(0.007)	(0.01)	
F	-3.10	0.39	-0.003	2.97**	1.69*	0.11	0.02	-0.04*	3,816
	(1.73)	(0.21)	(0.003)	(0.90)	(0.78)	(0.25)	(0.01)	(0.02)	
G	0.82	0.04	0.001	1.79**	N/A	-0.28*	-0.009	0.01	1,630
	(0.96)	(0.15)	(0.002)	(0.43)		(0.12)	(0.007)	(0.01)	
H	1.39**	0.08	0.0003	0.87**	N/A	-0.19*	-0.007**	0.003	4,678
	(0.30)	(0.04)	(0.0005)	(0.15)		(0.09)	(0.002)	(0.003)	
I	-1.99*	-0.03	0.0002	-0.62*	3.38**	-0.23**	0.008	-0.0003	3,726
	(0.77)	(0.11)	(0.001)	(0.30)	(0.39)	(0.06)	(0.006)	(0.007)	
All with complete data	-0.97	-0.04	0.002	0.73	1.99**	-0.14*	--	--	19,446
	(0.57)	(0.10)	(0.001)	(0.50)	(0.44)	(0.06)			
All with no demographic discontinuity	-0.84	-0.25*	0.004	0.09	3.26**	-0.17*	--	--	10,116
	(0.51)	(0.12)	(0.002)	(0.33)	(0.28)	(0.09)			

* Significant at 5% level. ** Significant at 1% level.

Table 9. Relationship between fraction of contributions going to Roth and the match threshold

Each row shows results from a separate regression where the dependent variable is the fraction of the total employee contribution rate (before-tax plus Roth plus after-tax) that goes to the Roth during the first pay period where the employee earns a match in the company indicated in the first column. The dependent variable takes values from 0 to 1. The sample is employees who enrolled in the 401(k) during the first two full calendar years after the Roth was introduced. The explanatory variables are a constant, the total employee contribution rate (which takes a value of 1 for a 1% contribution rate), a dummy for the contribution rate being above the match threshold, the interaction of the above two, age as of enrollment date, age squared, a male dummy, log of salary in the calendar year of enrollment, and log of tenure as of enrollment date. Standard errors are in parentheses below coefficient estimates.

Company	Contrib. rate	Rate > Threshold	Rate × (Rate > Threshold)	Age	Age^2	Male	log(Salary)	log(Tenure)	N
A	0.02**	0.11**	-0.02**	-0.02**	0.0002**	0.03**	-0.009	0.002	3,934
	(0.003)	(0.02)	(0.004)	(0.003)	($3.6e^{-05}$)	(0.007)	(0.009)	(0.002)	
B	0.03**	0.13*	-0.03**	-0.02**	0.0001*	0.02	-0.001	0.003	936
	(0.007)	(0.05)	(0.008)	(0.005)	($6.7e^{-05}$)	(0.02)	(0.01)	(0.004)	
C	0.06**	0.28**	-0.06**	-0.02**	0.0002**	-0.01	-0.03	-0.004	1,538
	(0.006)	(0.04)	(0.006)	(0.006)	($7.3e^{-05}$)	(0.02)	(0.02)	(0.004)	
D	-0.62**	-1.81**	0.62**	-0.01**	$9.2e^{-05}$*	0.07**	-0.04**	0.002	5,966
	(0.06)	(0.20)	(0.07)	(0.003)	($3.6e^{-05}$)	(0.009)	(0.006)	(0.002)	
F	0.009	0.07**	-0.008	-0.02**	0.0002**	0.05**	-0.003	0.0006	5,124
	(0.005)	(0.03)	(0.005)	(0.003)	($3.3e^{-05}$)	(0.01)	(0.006)	(0.003)	
H	-0.007	-0.008	0.006	-0.02**	0.0002**	0.008	N/A	-0.04**	3,992
	(0.004)	(0.04)	(0.004)	(0.003)	($3.8e^{-05}$)	(0.01)		(0.004)	

* Significant at 5% level. ** Significant at 1% level.

Figure 1. Average total contribution rate by hire cohort

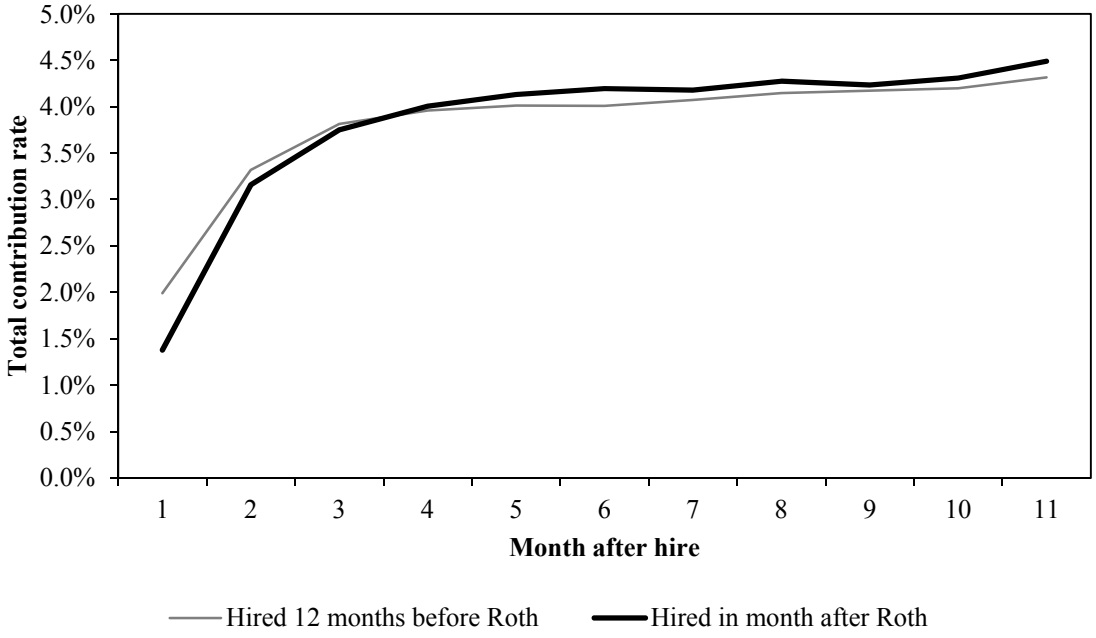

Figure 2A. Hire cohort estimates of Roth effect on total contribution rate against Roth participation rates in post-Roth hire cohort, 6 months after hire

The *y*-axis values are the individual company post-Roth hire cohort dummies from the regressions found in Table 5, Panel A. The *x*-axis values are the percent of the post-Roth hire cohort that has a positive Roth contribution rate at six months after hire.

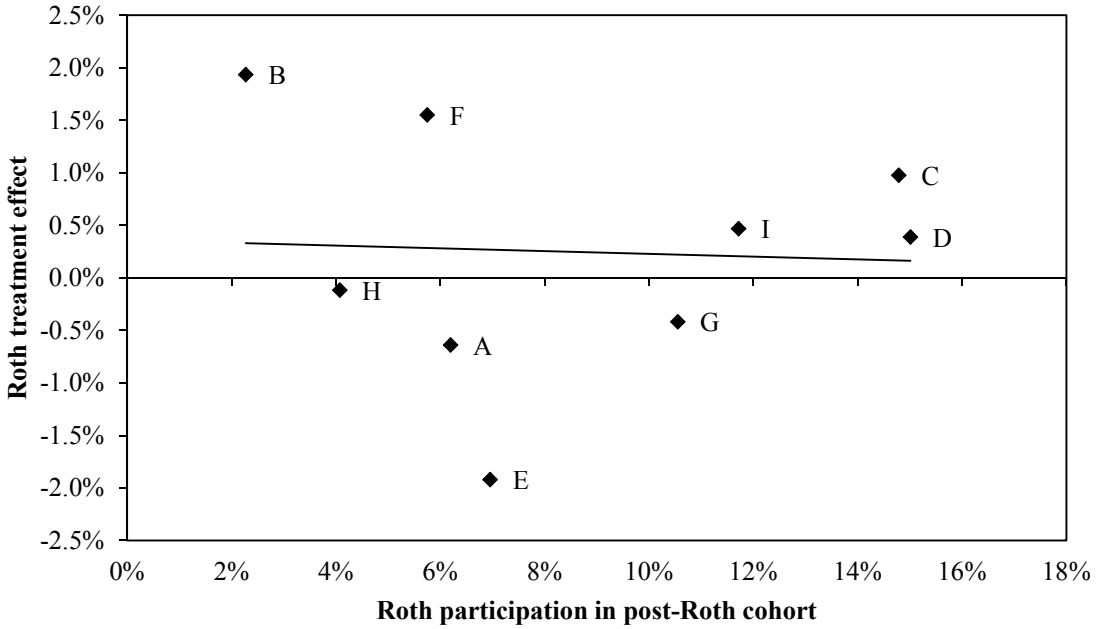

Figure 2B. Hire cohort estimates of Roth effect on total contribution rate against Roth participation rates in post-Roth hire cohort, 11 months after hire

The *y*-axis values are the individual company post-Roth hire cohort dummies from the regressions found in Table 5, Panel B. The *x*-axis values are the percent of the post-Roth hire cohort that has a positive Roth contribution rate at eleven months after hire.

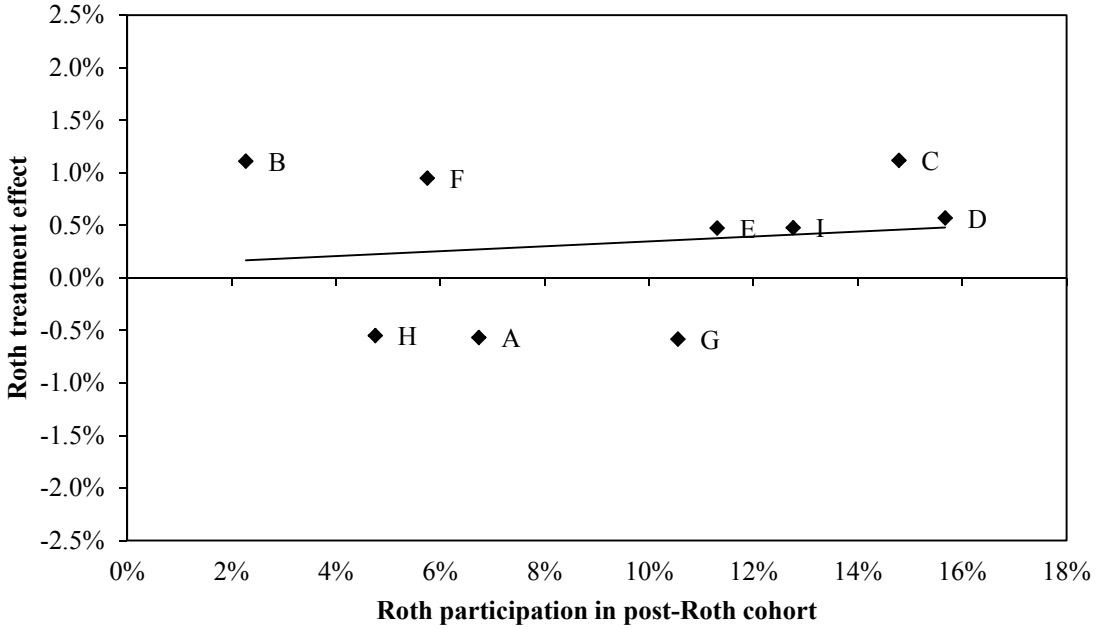

Figure 3. Enrollment cohort estimates of Roth effect on total contribution rate against percent of post-Roth enrollment cohort's contributions going to the Roth

The *y*-axis values are the individual company post-Roth enrollment cohort dummies from the regressions found in Table 8. The *x*-axis values are the average percent of the post-Roth enrollment cohort's contributions that are going to the Roth in the first month after Roth introduction.

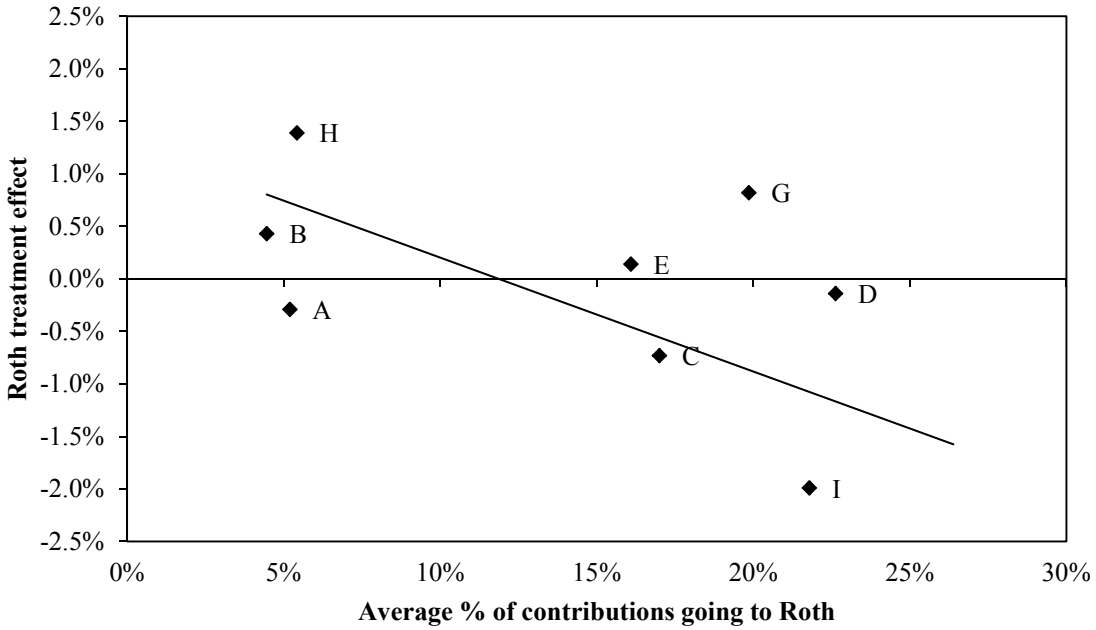

Figure 4. Example proportion of total employee contributions going to the Roth if employee compensates for match allocation

In this example, the employee wants 50% of all contributions to the account to go to the Roth. The employer match is 100% on the first 5% of income contributed.

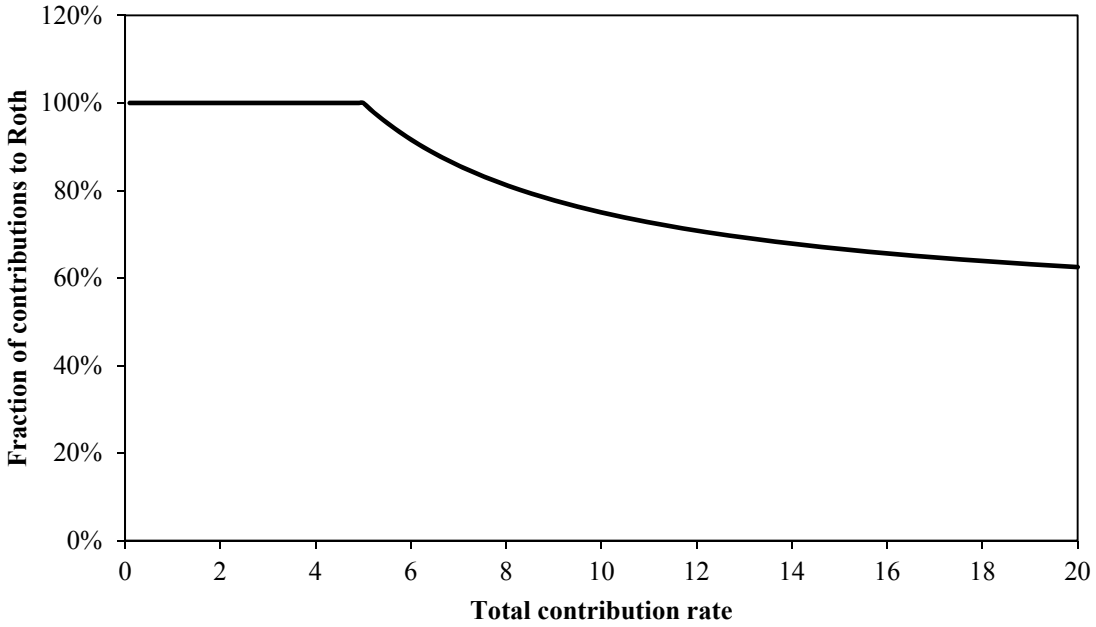

Figure 5. Roth participation rate among 2009 enrollees by age and income
The *y*-axis in these graphs is the percent of 2009 enrollees at all nine companies who contributed a positive amount to the Roth account anytime during 2009.