Does Front-Loading Taxation Increase Savings?
Evidence from Roth 401(k) Introductions

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Abstract: Can governments increase private savings by taxing savings up front instead of in retirement? Roth 401(k) contributions are not tax-deductible in the contribution year, but they are untaxed upon withdrawal in retirement. The more common before-tax 401(k) contribution is tax-deductible in the contribution year, but both principal and earnings are taxed upon withdrawal. Using administrative plan data from twelve companies that added a Roth option between 2006 and 2010, we find no evidence that total 401(k) contribution rates differ between employees hired before versus after the Roth introduction, which means that the amount of retirement consumption being purchased by 401(k) contributions increases after the Roth introduction. A survey experiment suggests two behavioral factors play a role in the unresponsiveness of contribution rates: (1) employee confusion about or neglect of the tax properties of Roth balances, and (2) partition dependence.

Keywords: Roth 401(k), tax salience, partition dependence

Choosing the right savings rate is complicated. As a result, 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 pre-tax income" (Choi et al., 2002; Benartzi and Thaler, 2007; Choi et al., 2013). These heuristics are not contingent on the tax treatment of the 401(k) account used. Even savings recommendations by sophisticated practitioners frequently do not vary according to how the savings vehicles used are taxed (e.g., Ibbotson et al., 2007).[1] If taxes are neglected when people make savings decisions, this raises the provocative possibility that relative to a system where savings are deductible from taxable income today and taxed in retirement, governments could increase the stock of private savings without affecting the present value of taxes by having people save using after-tax dollars today and then not taxing those savings in retirement.

The following two-period example illustrates how this mechanism would work. Suppose in period 1, an individual earns $100 of pre-tax income and the individual always saves 10% of his pre-tax income regardless of the tax rules. The income tax rate is 20%, and the rate of return from period 1 to 2 is r. If savings is tax-deductible initially and principal and earnings are taxed in period 2, then in period 1, the government collects $18, the individual saves $10, and the individual consumes $72. In period 2, the individual has $10 \times (1 + r) \times (1 - 0.2) = \$8 \times (1 + r)$ of savings available to consume, and the government collects $2 \times (1 + r)$ in taxes.

If, on the other hand, savings is not tax-deductible initially, but principal and earnings are not taxed in period 2, then in period 1, the government collects $20, the individual saves $10, and the individual consumes $70. In period 2, the individual has $10 \times (1 + r)$ of savings available to consume—a 25% increase over the first scenario. This increase occurs because period 1 savings did not fall in response to the fact that in the second scenario, each dollar of savings in period 1 buys more consumption in period 2, and it is financed by the $2 decrease in period 1 consumption necessitated by the non-deductibility of savings. The government collects $0 in taxes in period 2, but in both scenarios, the present value of taxes is the same: $20.

The introduction of Roth 401(k)/403(b) savings plans allows us to test whether the above mechanism plausibly exists. Since January 1, 2006, U.S. employers have been able to include a

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[1] See de Bartolome (1995), Duflo et al. (2006), Chetty, Looney, and Kroft (2009), Bettinger et al. (2009), Finkelstein (2009), Jones (2010), and Chetty and Saez (2013) for other examples of tax neglect.

Roth contribution option in their 401(k) or 403(b) retirement savings plan. The Plan Sponsor Council of America (2012) reports that 49% of 401(k) plans offered a Roth option in 2011. Like contributions to a Roth IRA, employee contributions to a Roth 401(k)/403(b) are not deductible from current taxable income, but withdrawals of principal, interest, and capital gains in retirement are tax-free. In contrast, before-tax 401(k)/403(b) contributions—the most common type of 401(k)/403(b) contribution—are deductible from current taxable income, but the entire principal and interest are taxed upon withdrawal. Therefore, a dollar of Roth balances purchases more retirement consumption than a dollar of before-tax balances. If people neglect taxes in making savings decisions, the total dollars contributed to the 401(k) will not change when a Roth becomes available, causing effective retirement savings to increase if some of those dollars are contributed to the Roth.

We use administrative 401(k) plan data from twelve companies that introduced a Roth 401(k) option between 2006 and 2010. We find no evidence that total contribution rates are different among employees hired in the month after a Roth option is introduced versus employees hired twelve months before. If anything, contributions rise slightly when the Roth is available. Our null finding does not appear to be driven by low adoption of the Roth option, since the Roth effect on total contributions is not decreasing across companies in the average Roth contribution rate in the post-Roth hire cohort.

The unresponsiveness of total 401(k) contributions to a Roth introduction could be the result of savings that would otherwise occur outside the 401(k) shifting into the 401(k). For example, Roth 401(k) contributions might replace Roth IRA contributions. We would not be able to observe such a shift because we only have 401(k) data. In addition, the introduction of the Roth weakly increases the employee's after-tax expected return from saving. If the substitution effect is large enough relative to the income effect, total desired savings weakly increases, and some of the increase might go into the 401(k). These forces could in combination fully offset the drop in 401(k) contributions that would otherwise be expected when a Roth becomes available.

To gauge the importance of these non-behavioral factors, we ran an online survey experiment. Respondents were asked to make a 401(k) contribution recommendation for a fictional couple, Jack and Cindy, for whom none of these considerations applied. Jack and Cindy have minimal existing savings and wish to do all of their saving over the next year in Jack's 401(k), so 401(k) contributions represent the couple's entire savings flow. In addition, Jack and

Cindy aim to have a material standard of living that does not change for the rest of their life (i.e., their substitution effect is zero). Respondents were randomly assigned to make this recommendation for a scenario where Jack and Cindy have access to (1) only a before-tax 401(k) account, (2) only a Roth 401(k) account, or (3) both before-tax and Roth 401(k) accounts.

We find that respondents do not significantly change their contribution rate recommendation when only a before-tax 401(k) is available versus only a Roth 401(k), suggesting that confusion about or neglect of the accounts' tax treatment is an important reason why we found no change in total contributions upon the Roth's introduction in the field data. In the before-tax-only scenario, the average recommended contribution rate is 10.4% of income, and in the Roth-only scenario, the average recommended contribution rate is 10.0% of income. Among the subsample that correctly answered more than three out of six questions about 401(k) contribution taxation rules, the average before-tax contribution recommendation is 11.9% of income and the average Roth contribution recommendation is 11.8%, indicating that even those who know the relevant tax rules neglect to take them into account when making 401(k) contribution choices.

Interestingly, when both accounts are available, respondents recommend a dramatically higher combined contribution rate: 13.9% of income. The increased total contribution recommendation when two accounts are available instead of one may be caused by partition dependence, which is the tendency for choices to be biased towards an equal allocation across all alternatives presented (Fox, Ratner, and Lieb, 2005). If current consumption is an allocation category in addition to the 401(k) account(s), then moving from two categories to three categories would cause the current consumption allocation to fall. Since in real life, a Roth 401(k) account is required by law to be offered in conjunction with a before-tax 401(k) account, partition dependence may be another force that attenuates the negative impact on contributions the Roth would otherwise be expected to have.

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 401(k) data. Section III discusses our estimates of the Roth 401(k)'s impact on total 401(k) contribution rates, and Section IV presents our survey experiment. Section V concludes.

I. The rules and economics of the Roth 401(k)[2]

We begin by describing the tax treatment of three different types of 401(k) contributions: Roth contributions, before-tax contributions, and after-tax contributions.

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 (i) the account has been held for at least five years and (ii) the account owner is either older than 59½, disabled, or deceased. Therefore, the marginal dollar 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 plus the marginal reduction in means-tested benefits (such as the Earned Income Tax Credit) due to the additional dollar of taxable income 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. For non-qualified withdrawals, the withdrawn principal is not taxed, but the interest and capital gains are subject to ordinary income tax and may reduce means-tested benefits and increase taxation of Social Security benefits received in the year of the withdrawal. 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, the marginal dollar of pre-tax income buys $(1 + r)(1 - \tau_1)$ of future consumption if it is contributed to a before-tax account, where τ_1 is the household's marginal ordinary income tax rate in the year of the withdrawal plus an adjustment if the withdrawal generates an increase in taxation of Social Security benefits or a reduction in means-tested benefits. An additional 10% tax penalty applies to both the principal and earnings withdrawn if the account owner is 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, and this interest and capital gains income may affect means-tested benefits and taxation of Social Security benefits. The marginal dollar of pre-tax income can buy $(1 - \tau_0)[1 + (1 - \tau_1)r]$

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[2] This section borrows heavily from Beshears et al. (2013a).

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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) and withdrawals occur late enough to be considered qualified by the Roth criteria, and investment earnings are positive, then saving the next pretax dollar in the Roth is a better financial deal than saving it before-tax if and only if $\tau_0 < \tau_1$. In a progressive tax system whose rules stay fixed over time, τ_1 will typically be less than τ_0 because non-401(k) income in retirement will typically be 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.[3]

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.

Although employers can structure their savings plans to allow Roth, before-tax, and after-tax employee contributions, employer matching contributions must 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 might not match certain types of employee contributions (e.g., after-tax contributions), but among the types of contributions 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)

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[3] McQuarrie (2008) also considers how tax laws may change in his analysis. Burman, Gale, and Weiner (1998) find that between 1980 and 1995, changes in tax laws had a much larger effect on individuals' marginal tax rates than variation induced by lifecycle income patterns. See Ahern et al. (2005) and Kotlikoff, Marx, and Rapson (2008) for other analyses of the relative merits of the Roth 401(k).

contribution dollar is being matched. To see this, let m be the rate at which employee contributions are matched. The marginal pre-tax dollar can earn m match dollars if it is saved using a before-tax account, but only $(1 - \tau_0)m$ match dollars if it is saved using a Roth or after-tax account (since τ_0 dollars must be paid in taxes and given up in government transfers, thereby preventing the entire dollar from being contributed to the savings plan). 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; with an employer match, the Roth is a better financial deal than contributing before-tax if and only if

$$(1 - \tau_0)[1 + m(1 - \tau_1)] > (1 - \tau_1)(1 + m). \tag{1}$$

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 $\tau_1 > 0$.[4]

Another factor affecting the attractiveness of Roth versus regular before-tax contributions is whether employees are constrained by the contribution limits on 401(k) plans. Internal Revenue Service regulations stipulate that the combined before-tax plus Roth contributions in a calendar year cannot exceed a certain limit that is adjusted each year. For people younger than 50, this limit was \$14,000 in 2005 (the last year before Roth contributions were allowed); it has been raised several times since then and stands at \$17,500 in 2013. People age 50 and older are allowed an additional "catch-up" contribution; this additional amount was \$4,000 in 2005 and has since been increased to its 2013 level of \$5,500. In addition to the limits on employee contributions, there is a limit on the combined employer plus employee contribution to 401(k) accounts. This aggregate limit was set at \$42,000 in 2005 and has since been raised to \$51,000 in 2013 for people under the age of 50. 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.

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

II. Data description

Our 401(k) administrative data come from Aon Hewitt, a firm with a large U.S. benefits administration and consulting business. We selected all companies in our database that introduced a Roth option to their 401(k) plan between 2006 and 2010 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, plan balances, birth date, hire date, salary (for nine of the twelve companies), and gender.[5] We restrict our sample to employees between the ages of 20 and 69.

Table 1 shows the characteristics of the twelve companies as of year-end 2010. In order to preserve these companies' anonymity, we refer to each company by the letters A through L and only disclose approximate employee counts. The companies are all large, ranging from approximately 10,000 employees to 100,000 employees. Eight of the twelve companies are in the financial services industry, and average salaries exceed $100,000 for Companies A, E, F, and I. Hence, the employees at these firms are likely to be more financially sophisticated than the typical U.S. employee. Average age ranges from 35 to 48 years; average tenure at the company ranges from five years to sixteen years; and male percentage ranges from 33% to 76%.

Table 2 summarizes the features of the 401(k) plan at each company as of 2010. Five companies introduced the Roth option in 2006, one in 2007, three in 2008, one in 2009, and two in 2010. Five companies automatically enroll their employees in the 401(k) at before-tax contribution rates of between 2% and 6% of income. The automatic enrollment companies have an average participation rate of 88%, which is higher than the average participation rate of 77% among the companies that have opt-in enrollment schemes. Nine companies match employee contributions up to a threshold between 3% and 8% of income at rates between 25% and 133%.

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[5] Month-end before-tax and after-tax contribution rates are missing in January 2006 for Company D. Month-end before-tax contribution rates are missing in April and June 2006 for Company G and in October 2007 for Company H. Month-end Roth contribution rates are often missing in our data for the first few months after the Roth is introduced at a company: from January to August 2008 for Company C, January to March 2006 for Company D, January to April and June 2006 for Company G, January to March 2006 for Company I, and January to February 2009 for Company J. 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. All contribution rates for a newly enrolled employee are also sometimes missing for the first few months after his or her enrollment, in which case we perform a similar imputation. Almost all of these missing new-enrollee contribution rates occur between January and March 2006 in Company I.

The maximum percent of a paycheck that can be contributed to the 401(k) ranges from 20% to 100%. These maximums are subject to IRS restrictions described earlier on the total dollars that can be contributed within a calendar year.

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

We estimate the impact of the Roth 401(k) on total contribution rates (before-tax plus after-tax plus Roth, if available) by comparing 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. Conditional on one's employer, whether one has access to the Roth immediately upon hire or one year after hire is plausibly orthogonal to one's savings preferences.

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, H, and L do not have salary data available. Six companies—B, C, E, F, G, and H—experienced no statistically significant changes in their observed variables. The other six 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 twelve companies together. The two lines lie nearly on top of each other, which is our first indication that total 401(k) contributions are unaffected by the Roth 401(k).

Table 4 shows the average total contribution rate comparisons separately for each company at six and eleven months after hire.[6] The only differences that are statistically significant at six months are at Companies A and B, where the post-Roth cohort contributes 1.22% of income less and 2.12% of income more than the pre-Roth cohort, respectively. At eleven months, the only significant differences are at Companies A and H, where the post-Roth cohort contributes 1.45% and 0.81% of income less, respectively. Pooling together all twelve

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[6] Appendix Table 1 shows the before-tax, after-tax, and Roth contribution rates separately for each hire cohort.

companies yields an insignificant average contribution *increase* of 0.01% and 0.07% of income among the post-Roth cohort at six and eleven months of tenure. Dropping the six companies with significant observable changes in employee characteristics across hire cohorts yields insignificant average contribution increases of 0.24% and 0.11% 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, a male dummy, and log salary. The regression results are qualitatively similar to the results from the simple mean comparisons. Out of 24 post-Roth hire cohort dummies (twelve at six months of tenure and twelve at eleven months of tenure), only one is significant at the 5% level, about what one would expect by chance. Pooling together all nine companies with complete employee demographic data and controlling for company dummies yields an insignificant total contribution rate increase in the post-Roth cohort of 0.14% and 0.37% of income at six and eleven months of tenure. Excluding companies with significant observable employee characteristic changes yields an insignificant total contribution rate increase of 0.23% at six months and 0.49% at eleven months.

This analysis indicates that the Roth 401(k) did not significantly 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. We would not expect total 401(k) contributions to change under a scenario where nobody contributes to the Roth. If insufficient Roth participation is responsible for our not being able to detect an overall negative effect on contribution rates, then we should at least observe a negative correlation between the Roth treatment effect at a company and the average Roth contribution rate at that company.

Figures 2A and 2B graph the estimated Roth introduction effect at each company against the average Roth contribution rate among the company's post-Roth cohort at six or eleven months after hire. The average Roth contribution rate ranges from 0.1% to 1.1% at six months, and that range broadens to between 0.1% and 1.6% at eleven months. The fitted regression lines indicate that weighting each company equally, there is an insignificant negative association between the estimated treatment effect and the average Roth contribution rate at six months after

hire (slope = -0.93, t = -1.46, p = 0.175) and an insignificant positive association at eleven months (slope = 0.69, t = 1.55, p = 0.153) after hire. At both horizons, the point estimate of the Roth introduction effect is positive at the three companies with the highest average Roth contribution rates. Overall, there is no evidence that our null Roth introduction effects are due to limited participation in the Roth.

We noted in Section I that the introduction of the Roth relaxes the effective 401(k) contribution limit because the same dollar limit applies to both Roth and before-tax contributions, and Roth dollars are more valuable than before-tax dollars. Suppose somebody with only a before-tax 401(k) contribution option would like to contribute $50,000 in before-tax dollars to the 401(k) in 2010. Because of the IRS contribution limit, he would contribute only $16,500 in before-tax dollars. Suppose instead that his company had introduced a Roth option at the beginning of 2010. He would then have chosen to contribute $16,500 in Roth dollars instead, because doing so gets him closer to the retirement consumption he would have been able to afford with a $50,000 before-tax contribution. For this person, the insensitivity of total contributions with respect to Roth availability is created by the fact that the contribution limits bind both with and without the Roth option.

Such a censoring mechanism is unlikely to explain why we find total contribution rate insensitivity in our data. In the calendar year of their hire, only 3.1% of employees in the pre-Roth hire cohorts across all our sample companies were either at the before-tax contribution limit, at the combined employee plus employer contribution limit, or were contributing the maximum percentage of salary allowed by their 401(k) for the entire year. This proportion is similar to the 2.8% of employees in the post-Roth hire cohorts who are analogously constrained. Appendix Table 2 shows tobit regressions that correspond to the contribution rate regressions in Table 5. Allowing for left-censoring at zero and right-censoring if the employee was at any of the relevant limits does not qualitatively change our estimates of the Roth introduction effect on total contribution rates.

IV. Survey experiment

Although we find that 401(k) contributions do not drop when a Roth option is introduced, our data cover only 401(k) contributions, so we do not know the extent to which the increased effective saving inside the 401(k) is offset by decreased saving outside the 401(k). Furthermore,

even if we knew that offset is minimal, we cannot tell from our data what mechanism generates the increased savings. Are employees increasing their effective savings because they are confused about the tax properties of Roth balances, or is this increase a rational substitution effect generated by the fact that the introduction of the Roth 401(k) weakly increases the after-tax return on saving?

To gauge how important savings offset and the substitution effect are for generating the insensitivity of total contribution rates to Roth introduction, we ran a pilot online experiment using participants from the Yale School of Management eLab subject pool, who each received a 10% chance of receiving a $10 Amazon.com gift certificate for completing a survey. Of course, survey responses raise questions of external validity because subjects' responses do not affect their economic outcomes and neighbors, co-workers, family, the media, and professional advisors influence individuals' financial choices in the field (Beshears et al., 2013b; Brown et al., 2008; Chalmers and Reuter, 2012; Duflo and Saez, 2002 and 2003; Engelberg and Parsons, 2011; Hong, Kubik, and Stein, 2004; Tetlock, 2007). Nonetheless, survey responses shed light on individuals' *intuitions* about optimal choices. Intuitive choices may serve as an initial anchor from which people adjust away, and this adjustment may be only partial (Tversky and Kahneman, 1974).

Respondents were randomly assigned to make a 401(k) contribution rate recommendation for a fictional couple with a relatively high income (and hence a positive current marginal tax rate) that has access to (1) only a before-tax 401(k) account, (2) only a Roth 401(k) account, or (3) both before-tax and Roth 401(k) accounts. This couple has minimal existing savings and wishes to do all of its saving over the next year in the husband's 401(k), so changes in the husband's 401(k) contribution rate represent the entire change in the couple's savings rate. In addition, their goal is to have a material standard of living that does not change for the rest of their life, which means that their substitution effect is zero. Since savings offset and the substitution effect are not operative in this scenario, if respondents understand 401(k) taxation and incorporate it in their thinking, they should recommend a lower total contribution rate in the experimental conditions where a Roth 401(k) is available.

Respondents in the before-tax-only condition saw the following text:

Jack and Cindy are married and have two children ages 2 and 4. They are both 30 years old and live in your neighborhood in rental housing. They don't expect to have any more kids.

Jack earns $100,000 per year before taxes working as a computer programmer and expects to retire at age 65. He expects his income to grow at the rate of inflation (that is, the rate at which the cost of living index rises) for the rest of his working life. Cindy is staying at home to raise their children and doesn't expect to return to the workforce.

The only savings Jack and Cindy have right now is $5,000 in a bank savings account. Jack's company offers a 401(k) retirement savings plan that has only a before-tax contribution option. Jack's company does not make matching contributions to the 401(k). This 401(k) also has a special rule: It does not allow Jack to withdraw money from it for any reason before he is 59.5 years old, even if Jack leaves the firm. (In real life, 401(k) withdrawal rules are not as strict.)

Jack and Cindy need to decide how much to contribute to the plan and how to invest the contributions. Their financial goal is to have a material standard of living that does not change for the rest of their lives, even in retirement. If they do save anything over the next 12 months, they plan on doing that saving in Jack's 401(k).

Please advise Jack and Cindy by recommending, to the best of your ability, a contribution amount and investment allocation. If you feel you need more information than we gave you, make whatever additional assumptions seem natural to you.

The first question asked, "What percent of Jack's $100,000 income should he contribute as a **before-tax** contribution to his 401(k) plan over the next 12 months? The maximum he is allowed to contribute is 17.5%. If you would like Jack to contribute nothing, the box must have a '0' in it." The second question asked, "What percent of Jack's 401(k) contributions should be invested in stocks? (The rest of the contributions will be invested in bonds.) Enter a number between 0 and 100."

Respondents in the Roth-only condition saw identical text, except we substituted in the sentence, "Jack's company offers a 401(k) retirement savings plan that only has a Roth contribution option (it only accepts after-tax dollars)." Respondents in the before-tax and Roth condition instead saw the sentence, "Jack's company offers a 401(k) retirement savings plan that allows both before-tax contributions and Roth (i.e., after-tax dollar) contributions." These subjects also saw the following sentence right before the final sentence: "We will ask you for two contribution rates—one for the before-tax contribution and one for the Roth contribution." Half saw the before-tax contribution rate entry box above the Roth contribution rate entry box,

and the other half saw the Roth contribution rate entry box above the before-tax contribution rate entry box.

After making their recommendations, respondents were asked questions about whether their household currently had access to a 401(k), 403(b), 457, or thrift savings plan; whether their household had currently had access to a Roth 401(k), 403(b), 457, or thrift savings plan; 401(k) taxation rules; general financial literacy questions; and their demographics. For brevity, we will refer to 401(k), 403(b), 457, and thrift savings plans as "401(k)-like plans." The appendix contains the entire survey text.

Our sample contains 419 respondents, of whom 204 report having access to a 401(k)-like plan and 112 (a subset of the 204) report having access to a Roth plan. These latter two subgroups are particularly interesting because we expect them to have the greatest knowledge about 401(k) plans and have thought the most about what optimal 401(k) contribution choices look like.

Figure 3 shows that there is no significant difference in the contribution rate recommended for a couple that has only a before-tax 401(k) option versus a couple that has only a Roth 401(k) option. Among the entire pool of respondents, the average recommended before-tax contribution rate is 10.4%, and the average recommended Roth contribution rate is 10.0%. Restricting the sample to those who have access to a 401(k)-like plan, the average recommendation is actually higher in the Roth-only condition—10.0% for the before-tax contribution rate and 10.2% for the Roth contribution rate—which is the opposite of what should occur if respondents were correctly taking into account the 401(k) taxation rules. This wrong-way gap widens to an 8.5% before-tax contribution rate and a 10.5% Roth contribution rate among those who should be in the position to make the most informed recommendation, respondents who have access to a Roth plan, although the difference between the two contribution rates is not statistically significant.

What explains the failure of the recommended contribution rate to fall in the Roth-only condition? One unlikely possibility is that the failure is due to the recommended asset allocation changing greatly between the before-tax-only and Roth-only conditions. According to the Euler equation, the optimal savings rate for an investor depends on the risk of her portfolio, so a dramatically different asset allocation could rationalize an effective savings rate that is much higher in the Roth-only condition. Figure 4 shows that respondents do recommend a lower

allocation to equities in the Roth-only condition than in the before-tax condition: 34% versus 44%, a difference that is significant at the 1% level. However, this difference narrows and loses significance among those who have access to a 401(k)-like plan, and narrows even further for those who have access to a Roth plan. If differing equity allocations were responsible for the similarity in the contribution rates across conditions, we should see the Roth-only contribution rate drop relative to the before-tax-only contribution rate as we move from all respondents to respondents with access to a 401(k)-like plan to respondents with access to a Roth plan. Instead, we saw in Figure 3 that Roth-only contribution rates rise as we restrict the sample.[7]

Another possibility is that respondents raise effective savings in the Roth-only condition because the Roth 401(k) penalizes early withdrawals more lightly than the before-tax 401(k), making contributions to the Roth more attractive. This explanation is highly unlikely for two reasons. First, the vignette explicitly stated that Jack's 401(k) does not allow early withdrawals for any reason. Second, few respondents know what the penalties associated with early withdrawal are. Table 6 shows that only 9% know what the tax penalty on a before-tax withdrawal at age 49 is, and only 2% know what the tax penalty is on a Roth withdrawal at age 49. This fraction rises only slightly as we restrict the sample to those who have access to a 401(k)-like plan or those who have access to a Roth plan. If we count not whether the above questions were answered absolutely correctly, but whether they were answered in a manner consistent with the belief that before-tax withdrawals are penalized more heavily than Roth withdrawals, the fraction counted knowledgeable is 9% in the full sample, 10% in the sample that has access to a 401(k)-like plan, and 12% in the sample that has access to a Roth plan.

A more likely possibility is that the insensitivity of contributions across conditions is driven by ignorance of the 401(k) tax rules, as shown in the remainder of Table 6. Only 47% of respondents know that making before-tax 401(k) contributions decreases taxable income in the year of the contribution, and only 38% know that making Roth 401(k) contributions does not affect taxable income in the year of the contribution. Knowledge of withdrawal rules in retirement is even lower. Twenty-eight percent can identify how much of a before-tax withdrawal at age 65 would be taxable income, and 19% can correctly answer an analogous

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[7] We also suspect that the significant difference in equity allocations is a Type I error. We ran an earlier pilot study on the Yale eLab sample that was identical to the current pilot study, except that the Jack and Cindy story did not specify that all their saving would happen in the 401(k). We had 260 respondents across the before-tax-only and Roth-only conditions. The average equity allocation in the before-tax-only condition was 34.5%, and the allocation in the Roth-only condition was 34.0%.

question about Roth withdrawals at age 65. Again, respondents who have access to a 401(k)-like plan or a Roth plan are barely more knowledgeable than the overall sample. Only 20% of the full sample give answers to the age-65 withdrawal questions that are ordinally correct, in the sense that a before-tax withdrawal adds more to taxable income than a Roth withdrawal. This percentage rises marginally to 22% when restricting to respondents who have access to a 401(k)-like plan or restricting to respondents who have access to a Roth plan.

However, when we split our sample between the 319 respondents who answered less than three of the taxation questions correctly and the 93 respondents who answered at least three of the taxation questions correctly, the relative pattern of contribution rate recommendations across conditions is similar across subsamples.[8] Among those with less knowledge, the average before-tax-only contribution rate recommendation is 9.9% and the average Roth-only contribution rate recommendation is 9.6%. Among those with more knowledge, the average before-tax-only contribution rate recommendation is 11.9% and the average Roth-only contribution rate recommendation is 11.8%. The fact that more knowledgeable individuals do not reduce their contribution recommendation by more in the Roth-only conditions suggests that even those who know the tax rules neglect to apply them to their recommendations, perhaps because the applicability of the tax rules is not immediately apparent.

Because by law, any employer that offers a Roth 401(k) must also offer a before-tax 401(k), the experimental condition where both a before-tax and Roth account are available most closely corresponds to the situation that faces employees hired right after a Roth 401(k) introduction. Figure 3 shows that respondents in this condition recommend much higher total contribution rates (significant at the 1% level) than in either the before-tax-only or Roth-only conditions: 13.9% across the entire sample, 13.9% among those who have access to a 401(k)-like plan, and 12.9% among those have access to a Roth plan. Figure 4 shows that recommended equity allocations are not significantly different in the before tax and Roth condition versus either the before-tax-only or Roth-only condition, and we see in Figure 5 that both less knowledgeable and more knowledgeable respondents recommend a higher total contribution rate in the before tax and Roth condition.

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[8] These groups together contain only 412 respondents because 7 respondents provided contribution rate recommendations but did not answer all of the taxation questions.

The rise in the recommended total contribution rate when two accounts are made available may be caused by the psychological phenomenon of partition dependence, which is the tendency of people to bias their choices towards equal allocations to each of the categories presented to them (Fox, Ratner, and Lieb, 2005). If consumption is a category that respondents are considering when making their contribution decision, then a bias towards equal allocation would reduce consumption when there are three categories considered (consumption, before-tax contribution, and Roth contribution) relative to when only two categories are considered (consumption and before-tax contribution or consumption and Roth contribution). Partition dependence may be a force that works in conjunction with tax neglect to prevent total contributions from falling when a Roth 401(k) is introduced.

V. Conclusion

We find no evidence that introducing a Roth 401(k) option affects total 401(k) 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. Our survey experiment suggests that employee confusion about or neglect of the tax properties of Roth balances and partition dependence play roles in the unresponsiveness of contribution rates. These results raise the possibility that governments may be able to increase private savings while holding the present value of taxes collected roughly constant by making savings non-deductible up front but non-taxable in retirement, rather than vice versa.

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Table 1. Company characteristics as of 2010

Company	Industry	Total employees	Average age	Median salary	Average salary	Average tenure	Percent male
A	Pharmaceutical	~ 50,000	43.1	$95,100	$106,089	10.6 years	54%
B	Financial services	~ 10,000	46.4	$77,079	$84,285	11.9 years	42%
C	Financial services	~ 25,000	44.9	$75,049	$86,705	13.4 years	54%
D	Financial services	~ 25,000	43.7	$54,687	$73,679	9.6 years	46%
E	Financial services	~ 50,000	35.0	$140,598	$295,206	4.9 years	61%
F	Financial services	~ 25,000	44.0	$80,304	$148,184	8.4 years	60%
G	Financial services	~ 10,000	47.5	N/A	N/A	12.2 years	53%
H	Financial services	~ 25,000	40.7	N/A	N/A	8.9 years	33%
I	Business services	~ 25,000	36.4	$83,900	$109,856	6.6 years	62%
J	Manufacturing	~ 25,000	46.6	$59,218	$74,808	16.0 years	65%
K	Manufacturing	~ 100,000	45.7	$67,694	$77,694	13.4 years	76%
L	Financial services	~ 10,000	42.3	N/A	N/A	8.1 years	35%

Table 2. 401(k) characteristics as of 2010

Company	Participation rate	Enrollment default	Employer match structure	Max contribution allowed (% of salary)	Roth 401(k) introduction date
A	84%	3% before-tax contribution rate	75% match on first 6% of income contributed after 1 year of tenure	50%	1/1/2008
B	98%	3% before-tax contribution rate	70% match on first 6% of income contributed	20%	9/1/2006
C	96%	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	82%	Non-enrollment	133% match on first 3% of income contributed after 1 year of tenure	45%	1/1/2006
E	49%	Non-enrollment	No match	50%	2/1/2006
F	75%	Non-enrollment	100% match on first 6% of income contributed after 1 year of tenure	100%	1/1/2007
G	88%	Non-enrollment	No match	20%	1/1/2006
H	74%	Non-enrollment	115% match on first 6% of income contributed after 1 year of tenure	20%	1/1/2008
I	86%	Non-enrollment	No match	50%	1/1/2006
J	90%	6% before-tax contribution rate	Either 70% or 100% match on first 6% of income contributed	35%	1/1/2009
K	74%	2% before-tax contribution rate	100% match on the first 2% of income contributed, 50% match on the next 2% of income contributed, and 25% match on the next 4% of income contributed	75%	1/1/2010
L	85%	Non-enrollment	50% match on the first 6% of income contributed	100%	7/1/2010

Table 3. Comparison of hire cohort characteristics

This table shows the average age as of hire date, average salary, 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. Salaries are calculated using fewer employees than in the last column because of missing data.

Company	Age Before Roth	After Roth	Change	Salary Before Roth	After Roth	Change	Percent male Before Roth	After Roth	Change	N
A	36.4	33.7	-2.75** (0.74)	$83,192	$65,121	-18,071** (3,420)	47.6	44.7	-2.91 (4.07)	603
B	36.2	38.3	2.15 (2.11)	$62,684	$67,462	4,778 (6,981)	39.0%	50.0%	10.98 (9.73)	120
C	34.4	34.4	-0.06 (1.28)	$55,820	$57,690	1,870 (3,957)	61.6%	63.2%	1.61 (5.88)	276
D	35.0	37.3	2.26** (0.83)	$39,133	$41,183	2,050 (3,304)	58.9%	46.7%	-12.12** (3.90)	652
E	31.2	29.5	-1.69 (0.94)	$184,811	$160,114	-24,697 (30,906)	60.6%	68.4%	7.83 (6.37)	226
F	35.9	36.1	0.21 (1.06)	$59,908	$66,787	6,879 (5,953)	58.0%	54.9%	-3.08 (4.74)	444
G	38.7	36.5	-2.21 (1.40)	N/A	N/A	N/A	46.9%	48.8%	1.92 (5.98)	285
H	33.6	33.1	-0.51 (0.77)	N/A	N/A	N/A	39.1%	42.2%	3.13 (3.55)	775
I	34.4	33.2	-1.18 (0.74)	$66,492	$78,773	12,281** (3,401)	58.2%	58.9%	0.70 (3.44)	904
J	35.5	37.7	2.28 (2.36)	$55,814	$74,345	18,531* (7,240)	64.3%	50.0%	-14.34 (11.19)	151
K	36.3	37.9	1.57* (0.68)	$59,479	$62,280	2,800 (1,812)	71.5%	74.6%	3.07 (2.52)	1,334
L	36.0	37.9	1.88 (2.36)	N/A	N/A	N/A	61.9%	41.2%	-20.73* (10.31)	93

* 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.

Company	Total contribution rate 6 months after hire			Total contribution rate 11 months after hire		
	Before Roth	After Roth	Change	Before Roth	After Roth	Change
A	7.48	6.53	-0.95* (0.46)	8.14	6.89	-1.25* (0.51)
B	5.40	7.50	2.10* (0.97)	5.21	6.53	1.32 (0.98)
C	5.89	6.67	0.78 (0.93)	6.19	6.91	0.72 (0.84)
D	3.45	3.63	0.18 (0.42)	3.88	4.31	0.43 (0.45)
E	7.26	5.97	-1.28 (1.33)	6.99	7.76	0.77 (1.47)
F	7.33	7.29	-0.04 (1.38)	9.86	9.02	-0.84 (1.89)
G	5.03	4.89	-0.14 (0.97)	5.35	4.92	-0.43 (1.03)
H	2.14	2.07	-0.07 (0.31)	2.94	2.16	-0.78* (0.32)
I	5.45	5.89	0.44 (0.52)	5.84	6.59	0.75 (0.55)
J	7.40	7.86	0.46 (1.39)	7.05	7.86	0.82 (1.30)
K	5.54	6.00	0.46 (0.30)	5.56	6.11	0.55 (0.31)
L	2.19	2.78	0.59 (0.97)	2.24	1.84	-0.39 (0.89)
All	5.25	5.26	0.01 (0.19)	5.68	5.75	0.07 (0.22)
All with no demographic changes	4.70	4.94	0.24 (0.40)	5.50	5.60	0.11 (0.49)

* 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). Standard errors are in parentheses.

Company	Roth	Age	Age^2	Male	log(Salary)	N
Panel A: Contribution rate 6 months after hire						
A	-0.109	-0.088	0.003	0.236	2.018**	519
	(0.489)	(0.217)	(0.003)	(0.477)	(0.594)	
B	1.373	-0.356	0.005	-0.294	4.209**	120
	(0.869)	(0.304)	(0.004)	(0.897)	(0.960)	
C	0.762	-0.270	0.005	-1.545	2.290*	275
	(0.908)	(0.321)	(0.004)	(0.933)	(1.018)	
D	0.398	0.270	-0.003	0.467	1.744**	650
	(0.411)	(0.144)	(0.002)	(0.407)	(0.241)	
E	-1.165	-0.548	0.012	0.491	-0.372	225
	(1.341)	(0.833)	(0.012)	(1.418)	(1.104)	
F	-0.146	0.416	-0.003	-0.443	0.161	441
	(1.384)	(0.436)	(0.005)	(1.475)	(0.878)	
G	0.244	0.333	-0.002	1.212	N/A	285
	(0.949)	(0.277)	(0.003)	(0.938)		
H	-0.045	0.355**	-0.004**	1.016**	N/A	775
	(0.306)	(0.103)	(0.001)	(0.311)		
I	0.094	-0.646**	0.009**	-0.592	4.371**	890
	(0.524)	(0.165)	(0.002)	(0.527)	(0.647)	
J	-0.543	-0.913**	0.013**	-0.761	3.692**	150
	(1.319)	(0.329)	(0.004)	(0.949)	(0.932)	
K	0.252	-0.298**	0.004**	-0.221	3.125**	1,326
	(0.287)	(0.083)	(0.001)	(0.315)	(0.246)	
L	0.439	0.098	-0.000	-0.158	N/A	93
	(1.005)	(0.345)	(0.004)	(0.990)		
All with complete data	0.143	-0.143*	0.003**	-0.243	2.237**	4,596
	(0.222)	(0.072)	(0.001)	(0.227)	(0.162)	
Complete data, no demographic changes	0.229	0.102	0.001	-0.395	0.623	1,061
	(0.684)	(0.236)	(0.003)	(0.711)	(0.441)	

Panel B: Contribution rate 11 months after hire						
Company	Roth	Age	Age	Male	log(Salary)	N
A	-0.536	0.079	0.001	0.786	1.727*	519
	(0.558)	(0.247)	(0.003)	(0.544)	(0.678)	
B	0.769	-0.125	0.002	-0.795	4.077**	120
	(0.916)	(0.320)	(0.004)	(0.945)	(1.011)	
C	0.726	-0.594*	0.009*	-1.139	2.605**	275
	(0.809)	(0.286)	(0.004)	(0.832)	(0.907)	
D	0.415	0.258	-0.003	0.173	0.646*	650
	(0.451)	(0.158)	(0.002)	(0.446)	(0.264)	
E	0.988	-1.020	0.019	-0.169	0.299	225
	(1.481)	(0.920)	(0.013)	(1.566)	(1.220)	
F	-0.978	0.672	-0.005	-0.400	0.297	441
	(1.899)	(0.598)	(0.007)	(2.025)	(1.205)	
G	-0.051	0.094	0.001	0.465	N/A	285
	(1.012)	(0.295)	(0.004)	(1.000)		
H	-0.781*	0.213*	-0.002	1.260**	N/A	775
	(0.314)	(0.106)	(0.001)	(0.320)		
I	0.381	-0.569**	0.008**	-0.039	4.332**	890
	(0.550)	(0.173)	(0.002)	(0.554)	(0.680)	
J	0.038	-0.890**	0.013**	-0.168	2.967**	150
	(1.228)	(0.307)	(0.004)	(0.883)	(0.868)	
K	0.359	-0.153	0.002*	-0.607	2.844**	1,326
	(0.295)	(0.085)	(0.001)	(0.324)	(0.253)	
L	-0.601	-0.154	0.003	-0.028	N/A	93
	(0.920)	(0.316)	(0.004)	(0.907)		
All with complete data	0.367	-0.031	0.001	-0.196	1.968**	4,596
	(0.262)	(0.085)	(0.001)	(0.269)	(0.192)	
Complete data, no demographic changes	0.493	0.184	0.000	-0.291	0.620	1,061
	(0.877)	(0.303)	(0.004)	(0.912)	(0.566)	

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

Table 6. Knowledge of 401(k) taxation rules

This table shows the percent of survey respondents who correctly answered each question about 401(k) taxation rules.

	All respondents	Respondents with access to 401(k)	Respondents with access to Roth 401(k)
What is the tax penalty for a before-tax withdrawal at age 49?	9%	12%	15%
What is the tax penalty for a Roth withdrawal at age 49?	2%	2%	5%
What is the effect of a before-tax contribution on taxable income in year of contribution?	47%	55%	53%
What is effect of a Roth contribution on taxable income in year of contribution?	38%	45%	45%
How much of a before-tax withdrawal at age 65 is taxable income?	28%	32%	30%
How much of a Roth withdrawal at age 65 is taxable income?	19%	21%	22%

# Figure 1. Average total contribution rate by hire cohort
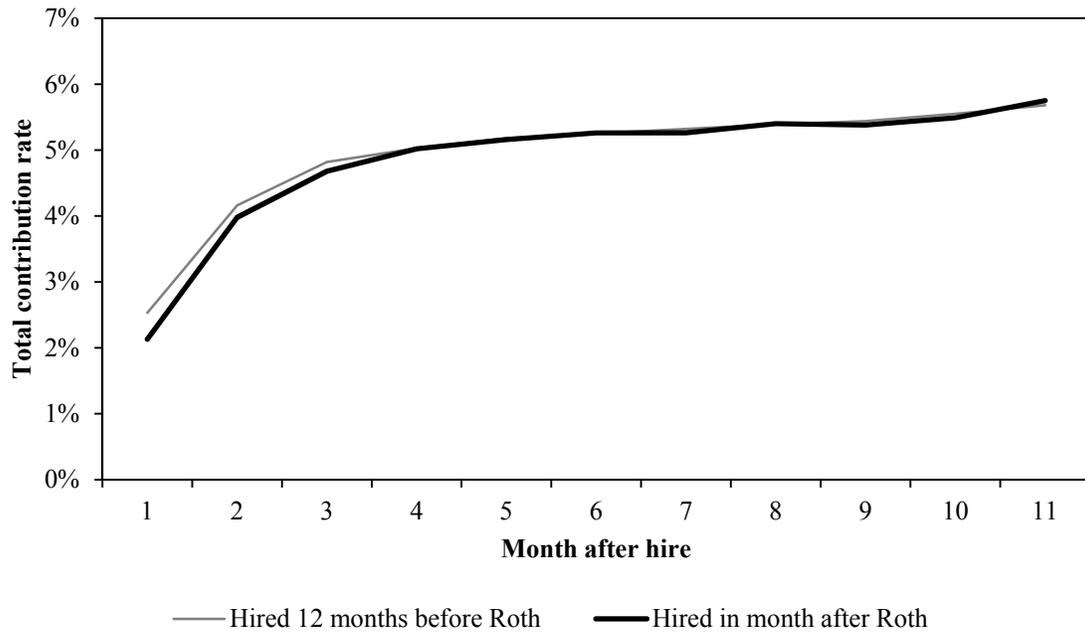
Figure 2A. Estimate of Roth effect on total contribution rate against average Roth contribution rate in post-Roth hire cohort, 6 months after hire
The *y*-axis values are the individual company post-Roth hire cohort dummy coefficients from the regressions found in Table 5, Panel A. The *x*-axis values are the average contribution rate of the post-Roth hire cohort at each company at six months after hire.
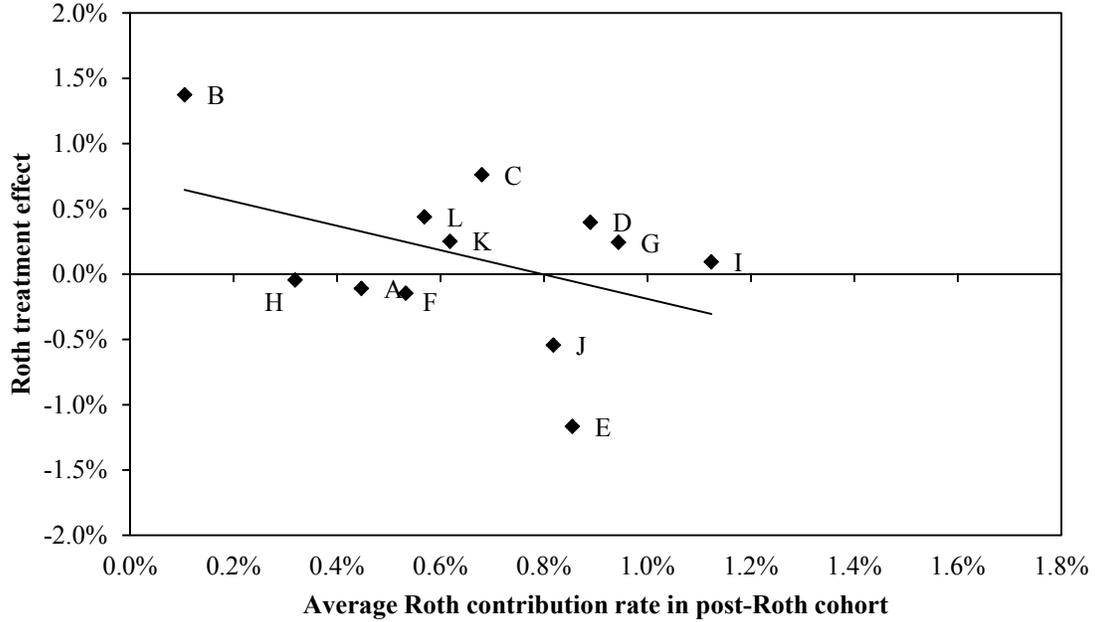
Figure 2B. Hire cohort estimates of Roth effect on total contribution rate against average Roth contribution rates in post-Roth hire cohort, 11 months after hire
The *y*-axis values are the individual company post-Roth hire cohort dummies from the regressions found in Table 5, Panel B. The *x*-axis values are the average contribution rate of the post-Roth hire cohort at each company at eleven months after hire.
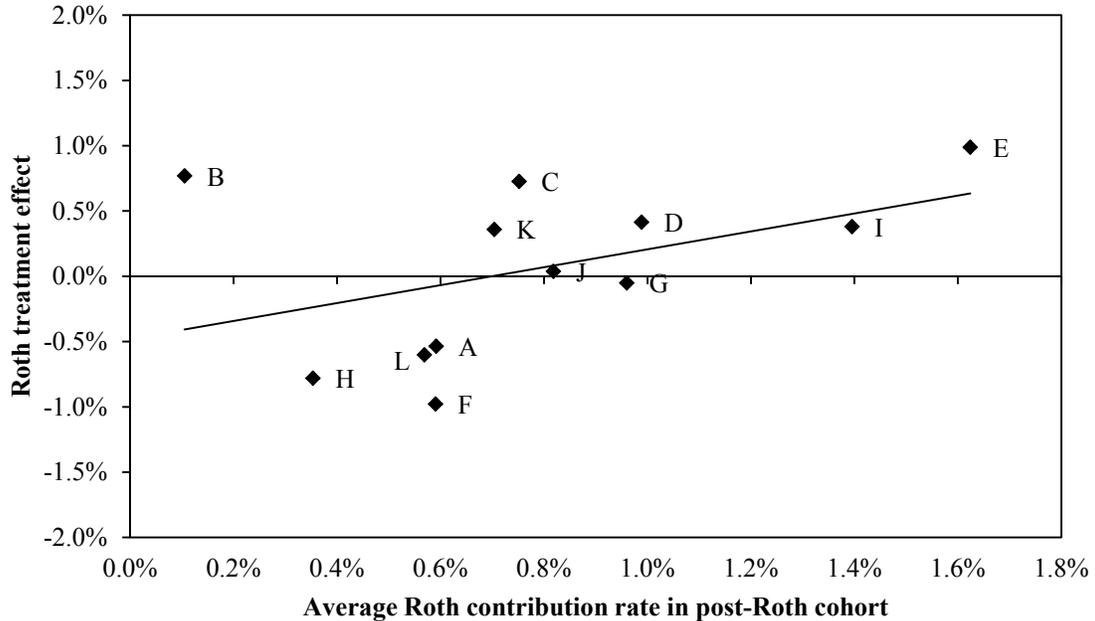
Figure 3. Average total contribution rate recommendations

Error bars show 95% confidence intervals.

All respondents   Has access to 401(k)   Has access to Roth 401(k)

■ Before-tax-only   ■ Roth-only   ■ Before-tax and Roth
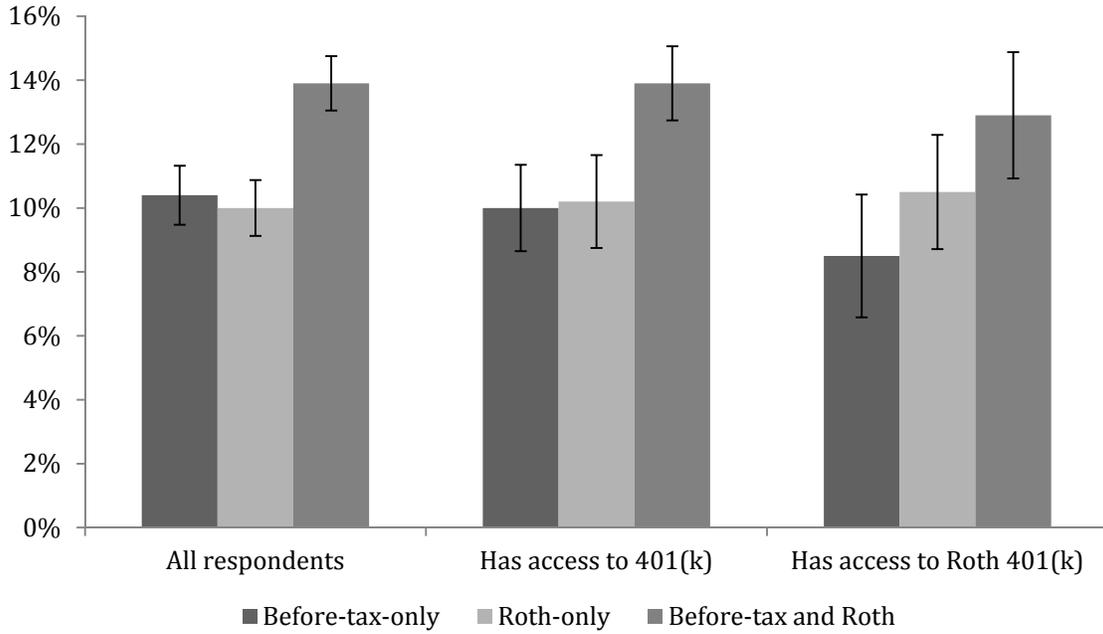
Figure 4. Average equity allocation recommendations

Error bars show 95% confidence intervals.

All respondents   Has access to 401(k)   Has access to Roth 401(k)

■ Before-tax-only   ■ Roth-only   ■ Before-tax and Roth
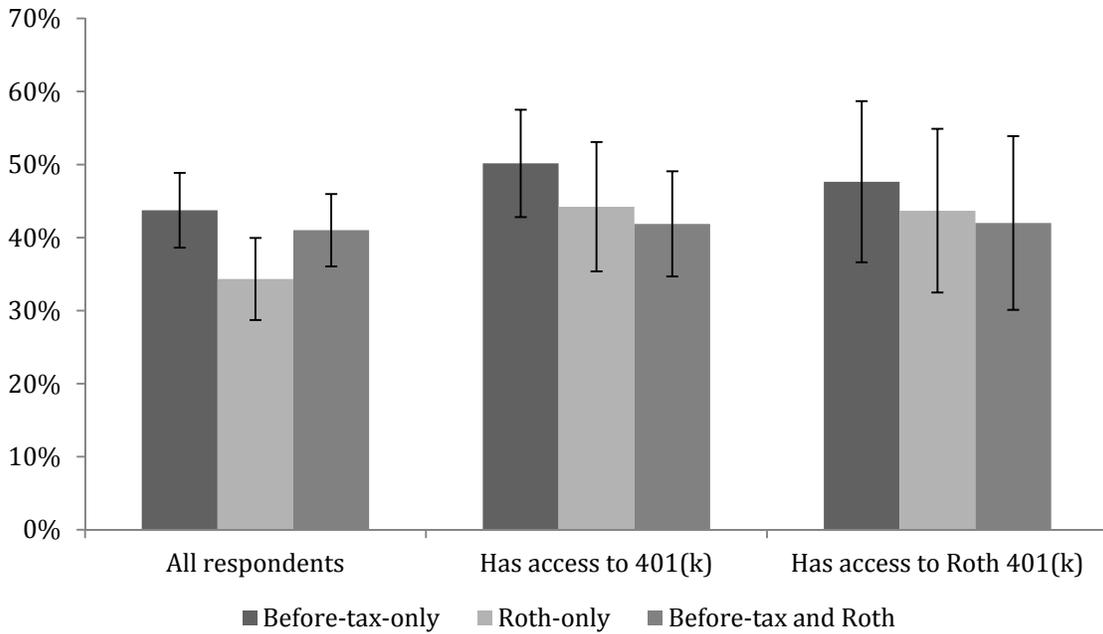
**Figure 5. Average total contribution rate recommendations
by knowledge of 401(k) taxation rules**

Error bars show 95% confidence intervals.
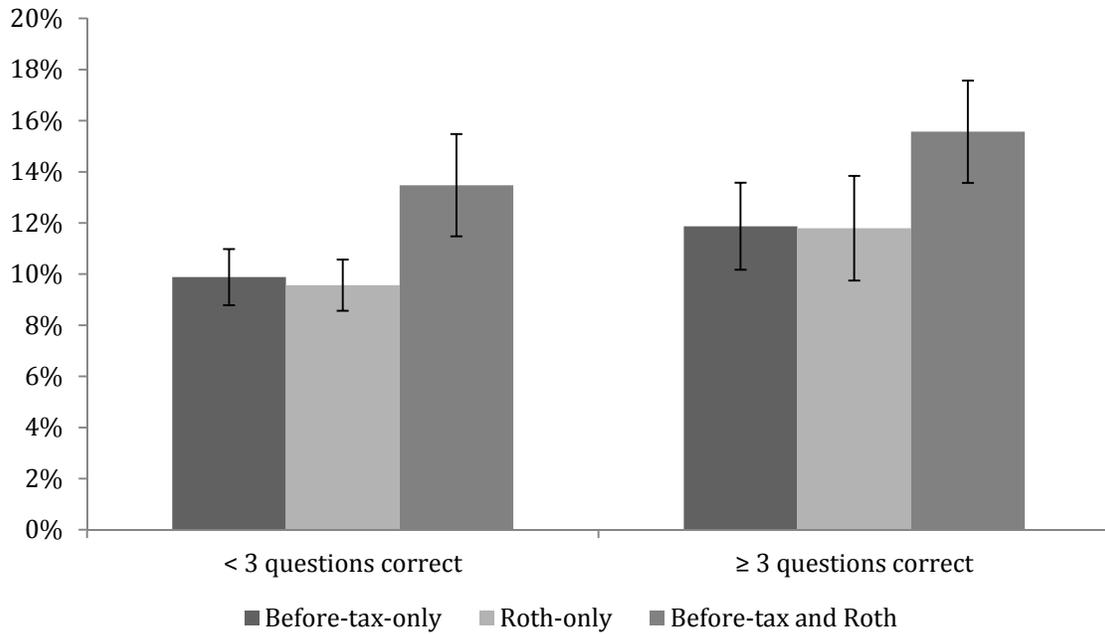
Appendix Table 1. Hire cohort average contribution rates by type

This table shows the average before-tax, after-tax, and Roth contribution rates 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 penultimate row in each panel shows the averages pooling all companies together, and the last row in each panel shows the averages excluding companies that had one or more significant demographic changes across the before and after hire cohorts in Table 3.

	Panel A: Contribution rates 6 months after hire					
	Hired in 12th month prior to Roth			Hired in month after Roth		
Company	Before-tax	After-tax	Roth	Before-tax	After-tax	Roth
A	7.27	0.21	0.00	5.93	0.16	0.45
B	5.23	0.17	0.00	7.32	0.08	0.11
C	4.90	0.98	0.00	5.46	0.54	0.68
D	3.39	0.06	0.00	2.56	0.18	0.89
E	7.26	0.00	0.00	5.12	0.00	0.85
F	7.11	0.22	0.00	6.71	0.05	0.53
G	5.03	0.00	0.00	3.94	0.00	0.94
H	2.14	0.00	0.00	1.75	0.00	0.32
I	5.45	0.00	0.00	4.77	0.00	1.12
J	7.11	0.29	0.00	7.05	0.00	0.82
K	5.35	0.19	0.00	5.25	0.14	0.62
L	2.19	0.00	0.00	2.16	0.06	0.57
All	5.11	0.14	0.00	4.49	0.10	0.67
All with no demographic changes	4.52	0.18	0.00	4.31	0.08	0.55

	Panel B: Contribution rates 11 months after hire					
	Hired in 12th month prior to Roth			Hired in month after Roth		
Company	Before-tax	After-tax	Roth	Before-tax	After-tax	Roth
A	7.86	0.28	0.00	6.16	0.13	0.59
B	5.12	0.09	0.00	6.34	0.08	0.11
C	5.30	0.89	0.00	5.69	0.47	0.75
D	3.75	0.12	0.00	3.19	0.13	0.99
E	6.99	0.00	0.00	6.14	0.00	1.62
F	9.64	0.22	0.00	8.38	0.05	0.59
G	5.35	0.00	0.00	3.96	0.00	0.96
H	2.94	0.00	0.00	1.80	0.00	0.35
I	5.84	0.00	0.00	5.19	0.00	1.40
J	6.71	0.33	0.00	6.95	0.09	0.82
K	5.45	0.11	0.00	5.28	0.12	0.70
L	2.24	0.00	0.00	1.22	0.06	0.57
All	5.55	0.13	0.00	4.85	0.09	0.80
All with no demographic changes	5.33	0.16	0.00	4.85	0.07	0.68

Appendix Table 2. Hire cohort tobit regressions

Each row is a tobit 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). Observations are left-censored at zero and right-censored if the employee is at a contribution rate maximum 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). Standard errors are in parentheses.

	Panel A: Contribution rate 6 months after hire					
Company	Roth	Age	Age^2	Male	log(Salary)	N
A	-0.083	0.029	0.002	0.321	2.607**	519
	(0.552)	(0.246)	(0.003)	(0.538)	(0.677)	
B	1.575	-0.398	0.006	-0.519	4.565**	120
	(0.928)	(0.326)	(0.004)	(0.963)	(1.031)	
C	1.916	-0.271	0.005	-2.172*	3.286**	275
	(1.075)	(0.380)	(0.005)	(1.100)	(1.207)	
D	0.332	0.410	-0.005	-0.132	5.337**	650
	(0.799)	(0.291)	(0.004)	(0.796)	(0.612)	
E	-2.641	-0.888	0.018	-0.196	2.977	225
	(2.659)	(1.656)	(0.024)	(2.787)	(2.276)	
F	0.507	0.968	-0.008	-3.849	4.430*	437
	(2.688)	(0.858)	(0.011)	(2.898)	(1.911)	
G	0.549	1.521**	-0.015*	2.050	N/A	285
	(1.549)	(0.494)	(0.006)	(1.527)		
H	-0.496	1.330**	-0.015**	3.798**	N/A	775
	(1.053)	(0.369)	(0.005)	(1.065)		
I	-0.306	-1.190**	0.016**	-1.000	9.875**	890
	(0.907)	(0.285)	(0.004)	(0.912)	(1.187)	
J	-0.751	-0.920*	0.014**	-0.951	4.034**	150
	(1.436)	(0.356)	(0.005)	(1.024)	(1.005)	
K	0.180	-0.303**	0.004**	-0.179	3.376**	1,326
	(0.312)	(0.090)	(0.001)	(0.342)	(0.270)	
L	0.651	0.799	-0.008	-1.182	N/A	93
	(2.557)	(0.932)	(0.012)	(2.523)		
All with complete data	-0.112	-0.188	0.003**	-0.316	4.202**	4,592
	(0.301)	(0.098)	(0.001)	(0.309)	(0.245)	
Complete data, no demographic changes	0.443	0.312	-0.001	-1.847	2.790**	1,057
	(1.053)	(0.365)	(0.005)	(1.096)	(0.734)	

Panel B: Contribution rate 11 months after hire					
Company	Roth	Age	Age^2	Male	log(Salary)	N
A	-0.562 (0.618)	0.124 (0.274)	0.001 (0.004)	0.974 (0.603)	2.501** (0.761)	519
B	0.901 (1.060)	-0.124 (0.372)	0.002 (0.005)	-1.089 (1.099)	4.573** (1.179)	120
C	1.364 (0.911)	-0.681* (0.326)	0.010* (0.004)	-1.426 (0.947)	3.594** (1.037)	275
D	0.806 (0.767)	0.504 (0.272)	-0.006 (0.003)	-0.128 (0.755)	0.767 (0.442)	650
E	0.620 (2.625)	-1.715 (1.621)	0.031 (0.023)	-1.442 (2.753)	3.388 (2.235)	225
F	0.739 (3.147)	0.845 (0.998)	-0.006 (0.012)	-3.681 (3.388)	6.125** (2.261)	437
G	-0.069 (1.565)	0.973* (0.476)	-0.008 (0.006)	1.304 (1.545)	N/A	285
H	-2.273** (0.830)	0.682* (0.281)	-0.007* (0.004)	3.631** (0.832)	N/A	775
I	0.031 (0.861)	-0.966** (0.272)	0.013** (0.003)	-0.159 (0.867)	9.119** (1.127)	890
J	-0.102 (1.308)	-0.861** (0.326)	0.013** (0.004)	-0.437 (0.942)	3.373** (0.922)	150
K	0.272 (0.319)	-0.160 (0.092)	0.002* (0.001)	-0.540 (0.349)	3.155** (0.277)	1,326
L	-1.754 (2.827)	0.063 (1.014)	0.001 (0.013)	-0.657 (2.798)	N/A	93
All with complete data	0.282 (0.321)	-0.029 (0.110)	0.002 (0.001)	-0.096 (0.345)	3.318** (0.248)	4,592
Complete data, no demographic changes	1.071 (1.255)	0.250 (0.433)	0.000 (0.006)	-1.689 (1.305)	3.324** (0.877)	1,057

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