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 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

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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 particular type of 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 governments could increase the after-tax stock of private savings without altering the present value of taxes by having people save with after-tax dollars today and then not taxing those savings in retirement, rather than allowing savings to be deducted from taxable income today and taxing them 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 are 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 are 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

[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 the marginal tax rate in retirement is positive. 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 due to the fact that the Roth 401(k) makes the 401(k) more attractive. Savings that would otherwise occur outside the 401(k) may shift into the 401(k). Because we have only 401(k) data, we would be unable to identify such a shift. 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 on 7,000 defined contribution plan participants. Respondents were asked to make a 401(k) contribution rate recommendation for a fictional couple, Jack and Cindy, for whom asset shifting and substitution effects are not relevant. Jack and Cindy earn $100,000 per year, 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 lives; that is, their substitution effect is zero. Respondents were randomly assigned to make a 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 also asked four questions to test knowledge of 401(k) tax rules.

Despite the absence of asset shifting and substitution effect considerations, we find that respondents barely decrease their average contribution rate recommendation from 11.2% of income when only a before-tax 401(k) is available to 10.7% of income when only a Roth 401(k) is available. This means that relative to the before-tax-only scenario, respondents are delivering less current consumption and more retirement consumption to Jack and Cindy in the Roth-only scenario if their marginal income tax rate today and in retirement is greater than 4.5%—conditions that are quite likely to be true.[2] Given Jack and Cindy's desire for a flat consumption path, moving present consumption and future consumption in opposite directions cannot be optimal; either respondents should deliver weakly more consumption to both periods or strictly less consumption to both periods. Consistent with confusion about 401(k) tax rules being an important reason why contribution amounts are unaffected by the Roth in field data, each of the four tax questions was answered correctly less than half the time. Among the least knowledgeable 45% of respondents, contribution recommendations fall by a statistically insignificant 0.4% of income as we move from the before-tax-only to the Roth-only condition. Among the next most knowledgeable subsample of 33%, contribution rate recommendations fall by a marginally significant 0.5% of income. And among the most knowledgeable 22%, contribution recommendations fall by a significant 0.9% of income. However, even a 0.9% drop is a very modest one, suggesting that those who know the relevant tax rules often neglect to take them into account when making 401(k) contribution choices

When both before-tax and Roth accounts are available and respondents are asked to type in a before-tax contribution rate and a Roth contribution rate without a preceding question about the total contribution rate desired, they recommend a before-tax plus Roth contribution rate that

[2] The lowest U.S. federal marginal income tax rate in 2014 is 10%. Only 3.7% of married U.S. households filing jointly with expanded cash income between $100,000 and $200,000 had zero or negative federal income tax liability in 2013 (Williams, 2013). Expanded cash income includes not only wages but also, among many other things, tax-exempt employer contributions to health insurance and the employer share of payroll taxes. See http://www.taxpolicycenter.org/taxtopics/Explanation-of-Income-Measures-2013.cfm.

is substantially higher than the contribution rate recommended in the single-account scenarios: 13.1% of income. Partition dependence (Fox, Ratner, and Lieb, 2005), which is the sensitivity of choices to the partitioning of the action space due to the psychological bias towards allocating an equal amount to each partition, appears to explain nearly all of this increase. If current consumption is an allocation category in addition to the 401(k) account(s), then moving from two partitions—{current consumption, before-tax} or {current consumption, Roth}—to the three partitions {current consumption, before-tax, Roth} would cause the allocation to current consumption to fall. Consistent with partition dependence causing nearly all of the contribution rate increase, when we instead ask respondents in the both-accounts condition for the recommended sum of the before-tax and Roth contribution rates—thus creating only the two partitions {current consumption, total 401(k) contributions}—respondents recommend a total contribution rate of 11.4%, which is close to the single-account conditions' recommendations. Since in actual 401(k) plans, a Roth account is required by law to be offered in conjunction with a before-tax account and employees are usually not asked to choose a total contribution rate before specifying how that contribution should be split between before-tax and Roth contributions, partition dependence may be a force that acts along with tax ignorance/neglect to create the (statistically insignificant) increase in total contributions we observe in our field data upon Roth introduction.

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)[3]

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

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

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 $(1 - \tau_0)[1 + (1 - \tau_1)r]$ 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 saving the next pre-tax 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.[4]

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) 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

[4] 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).

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

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

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 $\tau_1 > 0$.[5]

Another factor affecting the attractiveness of Roth versus 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.

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

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

participation status, plan enrollment date, monthly contribution rates, plan balances, birth date, hire date, salary (for nine of the twelve companies), and gender.[6] 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%. 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

[6] 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.

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 saving 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 the Roth 401(k) does not cause total 401(k) contributions to drop.

Table 4 shows the average total contribution rate comparisons separately for each company at six and eleven months after hire.[7] The only differences that are statistically significant at six months are at Companies A and B, where the post-Roth cohort contributes 0.95% of income less and 2.10% 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 1.25% and 0.78% of income less, respectively. Pooling together all twelve 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 at 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

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

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 whether employees increase their effective saving due to confusion about and neglect of the tax properties of Roth balances, or due to a rational substitution effect created by the Roth 401(k) increasing the after-tax return on savings.

To gauge how important savings offset and the substitution effect are for preventing a total contribution rate drop in response to Roth introduction, we ran an experiment within the Boston Research Group's online 2014 DCP Participant survey. The respondents were all current

participants in a 401(k), 403(b), 457, or profit-sharing plan whose record-keeper was one of 30 major record-keeping companies. 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; that is, their substitution effect is zero. The husband's 401(k) does not allow withdrawals before age 59½ for any reason, so the fact that early withdrawals from Roth balances bear a lighter tax penalty than early withdrawals from before-tax balances should play no role in the contribution rate recommendation. Other details of the vignette were chosen to make the couple's circumstances familiar ones to most respondents.

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 (it only accepts before-tax dollars). 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)," and asked for a Roth contribution rate. Respondents in the both-accounts 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." Half of subjects in this condition were asked to type in a before-tax contribution rate and a Roth contribution rate on the same screen in which the vignette text appeared. This elicitation mimics the usual way 401(k) contribution rates are elicited from employees. The other half of subjects were asked to first type in the *total* before-tax plus Roth contribution rate, knowing that they would specify on the next screen how this total contribution rate would be split between a before-tax contribution rate and a Roth contribution rate. After making their recommendations, respondents were asked two randomly selected questions out of four possible questions about 401(k) tax rules. The appendix shows the relevant questions' text.

Our sample contains 7,000 respondents, of whom 1,749 were in the before-tax-only condition, 1,750 were in the Roth-only condition, 1,750 were in the both-accounts condition and were asked to enter both contribution rates on the first screen, and 1,751 were in the both-accounts condition and were asked to enter only a total contribution rate on the first screen.

Figure 3 shows that despite the elimination of asset shifting and substitution effects, respondents recommend only a slightly lower contribution rate in the Roth-only condition than in the before-tax-only condition. The average recommended before-tax contribution rate is 11.2%, and the average recommended Roth contribution rate is 10.7% (p-value of difference = 0.002).[8] Therefore, relative to the before-tax-only condition, respondents are delivering more retirement consumption and less current consumption to Jack and Cindy in the very likely scenario that their marginal income tax rate currently and in retirement is greater than 4.5%. Moving current and retirement consumption in opposite directions cannot be the optimal solution, since Jack and Cindy want a flat consumption path. Respondents should either deliver weakly more consumption in both periods or strictly less consumption in both periods.

Why doesn't the recommended contribution rate fall more in the Roth-only condition? One possibility is that the recommended asset allocation changes 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 although respondents do recommend equity allocations that differ statistically between the two conditions (p-value of difference = 0.025), the gap is economically small: 42% in before-tax-only versus 39% in Roth-only.[9]

A more likely possibility is that the insensitivity of contributions across conditions is driven by ignorance and neglect of the 401(k) tax rules. Table 6 shows that only 49% of respondents know that making before-tax 401(k) contributions decreases taxable income in the year of the contribution, and only 46% know that making Roth 401(k) contributions does not affect taxable income in the year of the contribution. Because these two questions were multiple-

[8] We requested that contribution rate recommendations be entered in units such that "10" would correspond to 10%. A small number of people entered contribution rates between 0 and 1, probably because they misunderstood the units. We multiplied these responses by 100.

[9] As we did for contribution rate recommendations, we multiply the small number of equity allocation responses between 0 and 1 by 100.

choice questions with three options (corresponding to the contribution increasing taxable income, not affecting taxable income, and decreasing taxable income, plus an "I don't know" option), randomly guessing would have produced the correct answer 33% of the time. Knowledge of withdrawal taxation in retirement is also low. In free-response questions, 31% can correctly identify how much of a $150,000 before-tax withdrawal at age 65 would be taxable income, and 23% can correctly answer an analogous question about a $150,000 Roth withdrawal at age 65.[10]

Recall that each respondent answered only two randomly selected tax knowledge questions. Forty-five percent answered none of these two questions correctly, 33% answered only one question correctly, and 22% answered two questions correctly. We divide the sample by how many questions were answered correctly and show each group's total contribution rate recommendations in Figure 5. We see that the drop in the recommended contribution rate as we move from before-tax-only to Roth-only is 0.38% and insignificant ($p = 0.143$) among those who answered zero questions correctly, 0.54% and marginally significant ($p = 0.061$) among those who answered only one question correctly, and 0.85% and significant ($p = 0.025$) among those who answered two questions correctly. Although we do not have statistical power to reject the hypotheses that these three drops are equal to each other, this pattern suggests that tax ignorance plays an important role in the insensitivity of contribution rates to the tax treatment of 401(k) balances. Even the 0.85% drop in the most knowledgeable group is a quite modest one, implying that current consumption falls and retirement consumption rises if the marginal income tax rate in both periods is greater than 6.9%. This suggests that those who do know the relevant tax rules still often neglect to take them into account when making 401(k) contribution choices.

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. The third bar in Figure 3 shows that when the before-tax and Roth contribution rates are elicited in the usual way—without first asking respondents what the sum of the contribution rates will be—the average recommended total contribution rate is 13.1%, which is substantially higher than the recommended contribution rate in the two single-account conditions

[10] We counted the following responses to the before-tax withdrawal question as correct: 150,000; 100 (we assumed the respondent meant percent); 150 (we assumed the respondent was answering in thousands); 1,500,000 and 15,000,000 (we assumed the respondent mistyped extra zeros).

(*p*-value of difference with respect to either condition = 0.000).[11] This is puzzling because having both accounts available instead of only one weakly increases the after-tax rate of return on saving, so a couple like Jack and Cindy whose intertemporal elasticity of substitution is zero should weakly *decrease* its savings rate when moving from one account to two. Having both the before-tax and Roth accounts also allows one to diversify tax risk by contributing to both accounts. A decrease in investment risk is an additional force that should decrease saving for an agent with an intertemporal elasticity of substitution less than one (Weil, 1990).

A much more aggressive portfolio allocation in the both-account condition could potentially explain a higher contribution rate. But the recommended equity allocation of 45% in the both-accounts condition, although statistically distinguishable from the 42% allocation (*p*-value of difference = 0.003) in the before-tax-only condition and the 39% allocation in the Roth-only condition (*p*-value of difference = 0.000), is only slightly higher in economic terms. Neither is confusion about taxation a likely explanation: Figure 5 indicates that the rise in recommended contribution rate in the both-accounts condition is larger among the most tax-knowledgeable respondents.

In a pilot survey we ran before the survey reported in this paper, we observed that recommended total contributions rose in the both-accounts condition when contribution rates were elicited as above. We hypothesized that this rise was caused by the psychological phenomenon of partition dependence. Fox, Ratner, and Lieb (2005) show that since people have a bias towards allocating an equal amount to every discrete option presented to them, choices are sensitive to how the action space is partitioned.[12] If consumption is a category that respondents are considering when making their contribution decision, then a bias towards equal allocation would reduce consumption when the three partitions {current consumption, before-tax contribution, and Roth contribution} are considered relative to when only {consumption, before-tax contribution} or {current consumption, Roth contribution} are considered.

One way Fox, Ratner, and Lieb (2005) demonstrate partition dependence is by running an experiment where participants were asked to divide $2 among one international charity and four local charities. Participants who were asked to first decide on how much to allocate

[11] The 13.1% average total contribution rate is comprised of an 8.1% average before-tax contribution rate and a 5.0% average Roth contribution rate.

[12] Diversification biases do not necessarily cause people to allocate *exactly* an equal amount to each option, but rather bias their choices *towards* an equal allocation.

internationally versus locally before dividing the local allocation among the four local charities chose to give 52% to the international charity, whereas participants who were not prompted to follow this hierarchical procedure chose to give 21% to the international charity. This experiment motivated us to ask half of the respondents in our both-account condition to recommend a total 401(k) contribution rate before deciding how contributions would be split between before-tax and Roth contributions. We predicted that prompting respondents to think of the partitions {current consumption, total contribution} would elicit a total 401(k) contribution rate that is similar to the 401(k) contribution rate in the single-account conditions.

Indeed, Figure 3 shows that the average total contribution rate recommendation in the both-accounts condition when the total contribution rate was elicited first is 11.4%, which is not significantly different from the before-tax-only recommendation of 11.2% ($p = 0.166$), although it is significantly different from the Roth-only recommendation of 10.7% ($p = 0.000$).[13] The 41.0% equity allocation in this both-accounts elicitation is not statistically distinct from the before-tax-only allocation of 41.6% ($p = 0.565$) or the Roth-only allocation of 39.0% ($p = 0.087$). Because respondents in the two-stage elicitation could specify any combination of before-tax and Roth contribution rates that respondents in the one-stage elicitation could, we conclude that there is nothing about the economics of the both-accounts condition that makes a total contribution rate that is much higher than in the single-account conditions optimal. Instead, it appears that partition dependence can explain nearly all of the rise in total contribution rate that occurs when moving from a single-account condition to the both-accounts condition with a one-stage elicitation.

Because the companies in our field data that introduced a Roth probably used a one-stage elicitation for contribution rates, partition dependence may have played a role in preventing the total contribution rate from falling in the post-Roth hire cohort. In fact, total contribution rates rise (albeit not statistically significantly) in the post-Roth cohort, which is not something that tax neglect alone would produce but which partition dependence could.

[13] The 11.2% average total contribution rate is comprised of a 7.5% average before-tax contribution rate and a 4.0% average Roth contribution rate.

V. Conclusion

Comparing contribution rates of employees hired one year prior to Roth introduction to employees hired immediately after Roth introduction, we find no evidence that introducing a Roth 401(k) option decreases total 401(k) contribution rates. This means that the total amount of retirement consumption being purchased via the 401(k) increases after the Roth is made available. Our survey experiment suggests that employee confusion about and neglect of the tax properties of Roth balances and partition dependence are drivers of the unresponsiveness of contribution rates. These results raise the possibility that governments may be able to increase after-tax 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.

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

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

Panel A: Contribution rate 6 months after hire						
Company	Roth	Age	Age^2	Male	log(Salary)	*N*
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^2	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.

	Percent correct	N
Suppose a person with a $100,000 salary started making **before-tax** 401(k) contributions this calendar year without changing any of her contributions to other retirement savings accounts. What effect would this have on her taxable income this year?	49%	3,690
Suppose a person with a $100,000 salary started making **Roth** 401(k) contributions this calendar year without changing any of her contributions to other retirement savings accounts. What effect would this have on her taxable income this year?	46%	3,499
Suppose you made $100,000 in **before-tax** contributions to a 401(k) over the course of your working life. Your 401(k) investments went up in value, so that at age 65, your before-tax contributions are worth $150,000. You withdraw the entire $150,000 balance from your 401(k) at once **at age 65**. How much of this $150,000 withdrawal is taxable income in the year of the withdrawal?	33%	3,467
Suppose you made $100,000 in **Roth** contributions to a 401(k) over the course of your working life. Your 401(k) investments went up in value, so that at age 65, your Roth contributions are worth $150,000. You withdraw the entire $150,000 balance from your 401(k) at once **at age 65**. How much of this $150,000 withdrawal is taxable income in the year of the withdrawal?	25%	3,425

Figure 1. Average total contribution rate by hire cohort

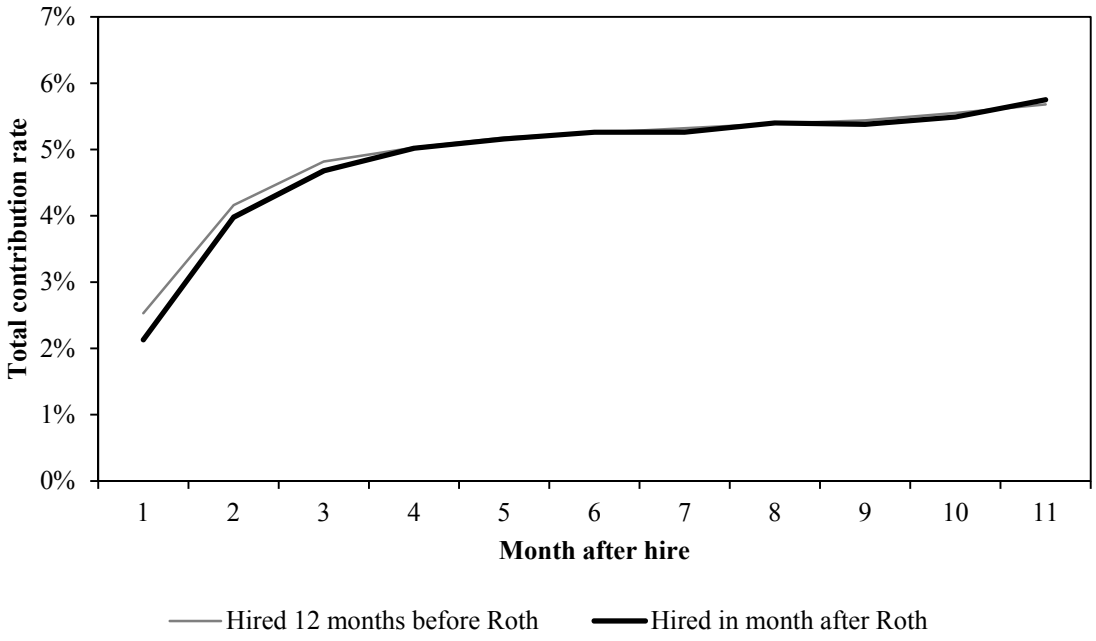


Figure 2A. Estimate of Roth effect on total contribution rate against average Roth contribution rate in post-Roth hire cohort, 6 months after hire

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.

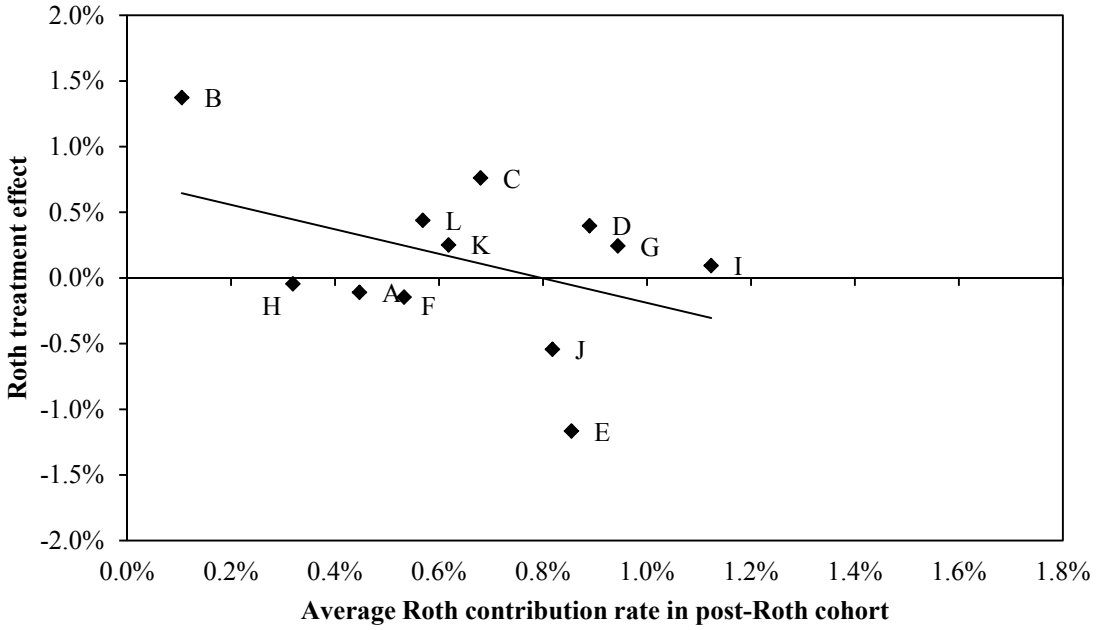


Figure 2B. Hire cohort estimates of Roth effect on total contribution rate against average Roth contribution rates in post-Roth hire cohort, 11 months after hire

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.

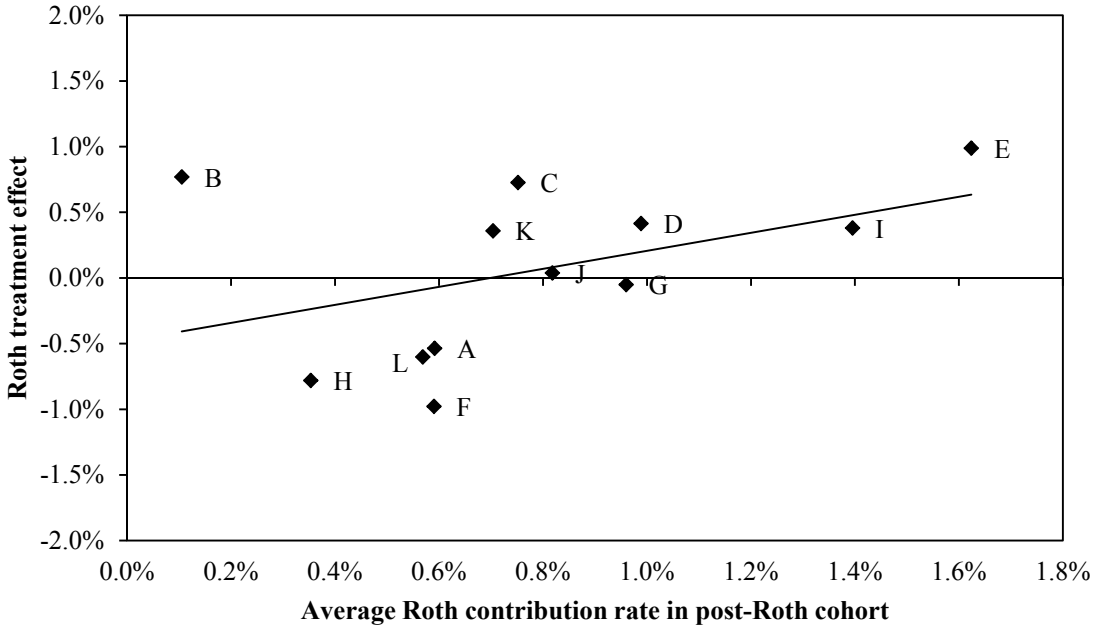


Figure 3. Average total contribution rate recommendations

Error bars show 95% confidence intervals.

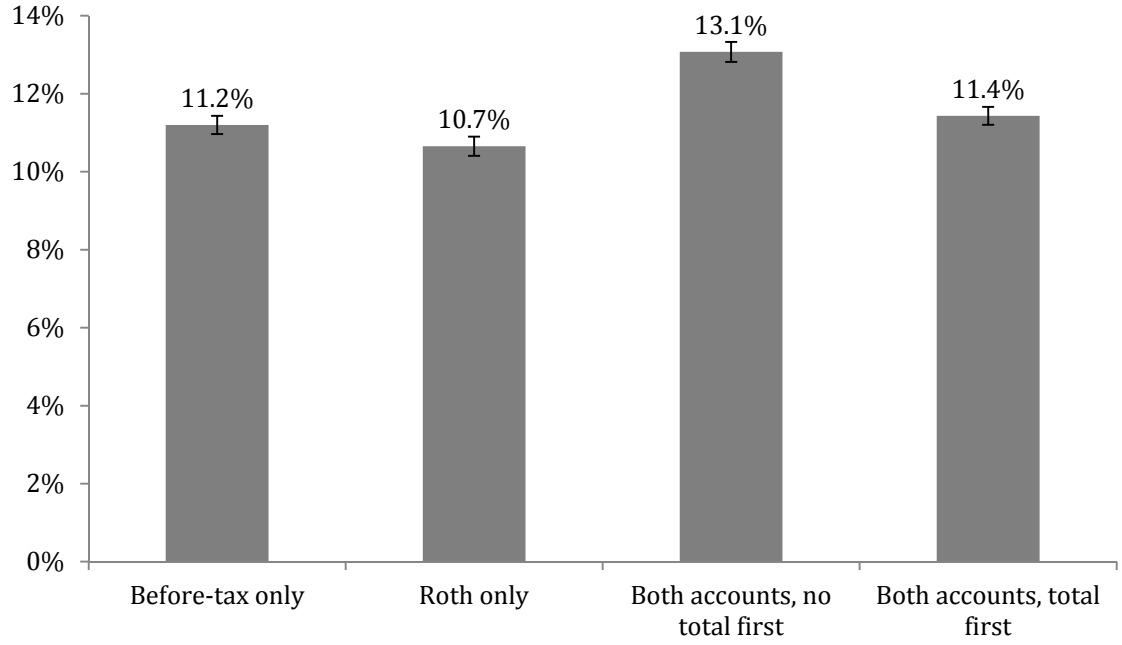


Figure 4. Average equity allocation recommendations

Error bars show 95% confidence intervals.

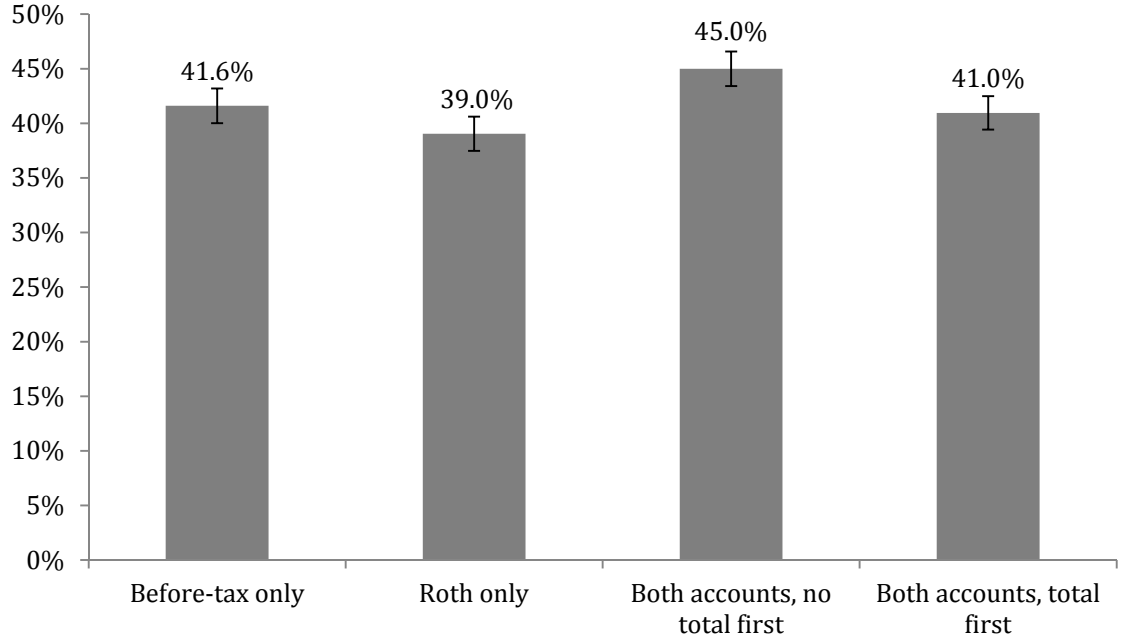
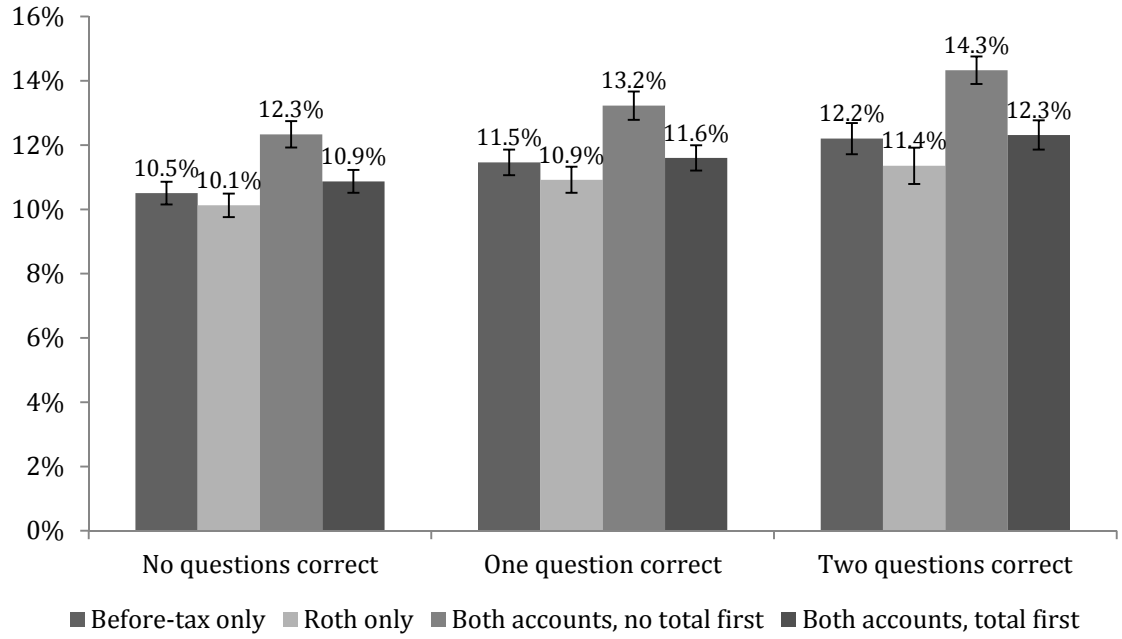


Figure 5. Average total contribution rate recommendations by knowledge of 401(k) tax rules

Error bars show 95% confidence intervals.



Online appendix

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

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

Survey experiment questions

[Each respondent was randomly assigned to be asked only one of questions 1-4]

1. 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 (it only accepts before-tax dollars). 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.

   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.

   _____%

2. 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 Roth contribution option (it only accepts after-tax dollars). 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.

What percent of Jack's $100,000 income should he contribute as a **Roth** 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.

_____%

3. 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 allows both before-tax contributions and Roth (i.e., after-tax dollar) contributions. 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. We will ask you for two contribution rates -- one for the before-tax contribution and one for the Roth contribution. If you feel you need more information than we gave you, make whatever additional assumptions seem natural to you.

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?

What percent of Jack's $100,000 income should he contribute as a **Roth** contribution to his 401(k) plan over the next 12 months?

The maximum combined amount he is allowed to contribute is 17.5%. If you would like Jack to contribute nothing, both boxes must have a "0" in them.

Before-tax contribution percentage _____%

Roth contribution percentage _____%

4. 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 allows both before-tax contributions and Roth (i.e., after-tax dollar) contributions. 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.

What percent of Jack's $100,000 income should he contribute **in total** 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. On the next screen, we will ask you how Jack should split his contributions between before-tax and Roth contributions.

_____%

5. 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.

_____

[*Question 6 was asked only of respondents who were assigned to answer question 4. It appeared on a separate screen from question 4.*]

6. You recommended that Jack contribute [*fill in response from question 4*]% of his income in total to the 401(k). What percent of Jack's income should he contribute as a before-tax contribution versus a Roth contribution? The numbers you type in the two boxes below must add up to *[fill in response from question 4]*.

   Before-tax contribution percentage _____%

   Roth contribution percentage _____%

7. Suppose you made $100,000 in **before-tax** contributions to a 401(k) over the course of your working life. Your 401(k) investments went up in value, so that at age 65, your before-tax contributions are worth $150,000. You withdraw the entire $150,000 balance from your 401(k) at once **at age 65**. How much of this $150,000 withdrawal is taxable income in the year of the withdrawal?

   ☐I know the answer (Please type the dollar amount below)

   _____

   ☐I don't know

8. Suppose a person with a $100,000 salary started making **before-tax** 401(k) contributions this calendar year without changing any of her contributions to other retirement savings accounts. What effect would this have on her taxable income this year?

   ☐ It would **increase** her taxable income this year

   ☐ It would have **no effect** on her taxable income this year

   ☐ It would **decrease** her taxable income this year

   ☐ I don't know

9. Suppose you made $100,000 in **Roth** contributions to a 401(k) over the course of your working life. Your 401(k) investments went up in value, so that at age 65, your Roth contributions are worth $150,000. You withdraw the entire $150,000 balance from your 401(k) at once **at age 65**. How much of this $150,000 withdrawal is taxable income in the year of the withdrawal?

   ☐ I know the answer (Please type the dollar amount below)

   _____

   ☐ I don't know

10. Suppose a person with a $100,000 salary started making **Roth** 401(k) contributions this calendar year without changing any of her contributions to other retirement savings accounts. What effect would this have on her taxable income this year?

    ☐ It would **increase** her taxable income this year

    ☐ It would have **no effect** on her taxable income this year

    ☐ It would **decrease** her taxable income this year

    ☐ I don't know