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ABSTRACT

Although supplemental saving plans can be an important part of an individual's financial security in retirement, contribution rates remain low, particularly among those with lower salaries and less education. We report findings from a field experiment that distributed an informational nudge containing information on key aspects of the employer-provided supplemental saving plans of older public employees in North Carolina. Among workers participating in a supplemental plan, individuals who received an informational nudge increased their contributions in the months following the intervention relative to the control group. Moreover, those that received the nudge reported in a subsequent survey that they were more likely to have developed a retirement plan and report more confidence in their retirement preparedness. In contrast, individuals who were not enrolled in a retirement saving plan were not moved to begin contributing to a supplemental plan.

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Nudging Retirement Savings: A Field Experiment on Supplemental Plans

I. Introduction

Ensuring adequate retirement income is of foremost policy importance. But there is a tradeoff between financial security during an individual's working years and financial security in retirement. We present results from a field experiment that was designed to spur individuals to reassess their retirement savings decisions. We interpret the results of this informational nudge in the context of the tradeoff between saving for the short/medium-term (for consumption during working years) and saving for the long-term (to provide income for the retirement years).

Our intervention targeted public sector workers in North Carolina who were more than 50 years old. By focusing on older workers, we examine the role of informational nudges in the context of individuals who may be hard to encourage to increase their rate of savings. We expect that older workers are hard-to-nudge because their tenure in the workforce has given them numerous opportunities to formulate and implement retirement plans or to indicate their unwillingness to engage in saving additional funds for retirement. Workers who have for years declined the opportunity to enroll in a retirement saving plan may be expressing their preference for current consumption over saving for additional consumption in retirement. In fact, Biggs (2017) concludes that if low income, working-age households reduce their take-home pay in order to contribute to retirement plans their standards of living in retirement may exceed that while they are working. Thus, it may not be surprising that public employees with lower earnings have optimally chosen not to contribute to a supplemental retirement saving plan. These workers are included in Social Security and are covered by a defined benefit pension. Our study explores this concern directly by asking whether individuals have engaged in retirement planning and whether they feel they have accumulated sufficient retirement wealth.

Alternatively, older workers may be resistant to changing saving behavior because the framing of policy interventions typically emphasizes compound interest as the key benefit of saving for retirement. This incentive is less important for older workers who have fewer remaining years to build savings (Clark, et al., 2014). Although compounding is an important benefit of retirement plans, older workers still experience several benefits from savings in employer-provided retirement plans. We designed our informational nudge to emphasize the benefits that older workers experience from increased retirement savings. For example, individuals may find that primary employer-provided defined benefit pension plans are inadequate to insure against longevity risk. Cost-of-living adjustments (COLA's) are typically not guaranteed and usually are less than the annual increase in the Consumer Price Index leaving individuals susceptible to inflation risk in retirement.

Further, individuals may have not anticipated cost of medical expenditures in late life and thus find that income from Social Security and employer pensions is insufficient to achieve the desired level of consumption or to cover an unanticipated health or income shock at older ages. Thus, supplemental retirement saving plans can help workers obtain sufficient wealth prior to retirement and insure against unexpected health or income shocks.[1] Further, contributions can be made pre-tax and grow tax-deferred until withdrawal. We present results from a field experiment that was designed specifically to spur older workers to reassess their retirement savings decisions highlighting these alternative motivations for participation in retirement saving plans.

[1] Throughout this discussion, the term "supplemental retirement saving plans" refers to employer-provided retirement saving plans such as 401(k) and 457 plans that are based on payroll deductions as contributions to the plans.

Voluntary saving plans may be underutilized due to insufficient understanding of these plans, behavioral biases that lead to inaction, or a lack of financial literacy. Choi, Laibson, and Madrian (2004) show the importance of clarity in plan design. Behavioral factors associated with undersaving include hyperbolic discounting (Laibson, 1997), a lack of self-control (Thaler and Shefrin, 1981), and procrastination (Choi, Laibson, Madrian, and Metrick, 2003). Further, the behavior economics literature has stressed the role of framing, which matters for retirement savings as well. For example, Goldin, Homonoff, and Tucker-Ray (2017) find larger responses to a nudge that emphasized low rather than high contribution rates. Finally, financial literacy has been shown to play an important role in saving and other financial decisions and increased financial literacy has been promoted as a policy priority (Lusardi, 2005; Van Rooij, Lusardi, and Alessie, 2012; Hastings, Madrian, and Skimmyhorn, 2013; Lusardi and Mitchell, 2014.). On the other hand, non-participation or participation at low levels could be the result of a well-formulated retirement plan, and individuals may have adequate wealth accumulated through outside savings vehicles and pension plans.

Our field experiment sent several versions of an informational nudge to randomly selected groups of older North Carolina state employees. Our experimental design tailored one set of nudges to workers with positive balances in a supplemental saving plan (participants) and a different set of nudges to workers without savings in a supplemental plan (non-participants). Our treatments provided information to older workers with an emphasis on either tax advantages, longevity risk, personalized risk selection, or liquidity. Among participants, we find a small and statistically significant impact on retirement savings among treated workers. We also find an increase in reports of having made a retirement plan and higher confidence in retirement income sufficiency. Non-participants did not respond to our intervention either in saving or planning

behavior. This is consistent with the fact that non-participants who are over age 50 have consistently decided over many years not to contribute to a retirement saving plan.

Importantly, we also observe some individuals decreasing retirement saving contributions after receiving the nudge. This suggests an alternative explanation of why older workers are hard to "nudge" into savings. Hard-to-nudge groups have been treated in the literature as requiring alternative nudge strategies to affect behavior in ways that achieve policy objectives. In this case, our hard-to-nudge group of older workers may be responding in ways that are individually optimal.[2] Thus, we interpret the success of the experiment as twofold. First, a small but significant number of older workers increased retirement savings due to receiving a nudge. Second, a larger fraction of those receiving a flyer were induced to reassess their retirement savings and engage in retirement planning. Low cost interventions like these flyers are shown to be a valid tool to improve retirement income security when targeted to individuals who are already engaged in the saving process.

II. Background on Supplemental Saving Plans

This study considers state government employees in North Carolina. North Carolina is a particularly interesting state to study given its large size and mix of urban and rural population. All state employees in North Carolina are covered by a standard defined benefit pension plan and retiree health insurance. State employees in North Carolina also have access to two state-

[2] This interpretation follows the argument of Bernheim and Rangel (2005) to interpret the results of policy interventions without paternalistic prior beliefs on welfare enhancing behavior at the individual level.

managed supplemental retirement saving plans: NC 401(k) or NC 457. Both plans are managed by Prudential and have similar investment options.[3]

Individuals contribute a fraction of their salary to an account that accumulates without any tax on investment returns until the time of the withdrawals. Both 401(k) and 457 plans allow employees to make pre-tax contributions. The North Carolina plans also offer Roth options that allow employees to contribute after-tax dollars to the plan. At the time of the experiment in 2014, annual dollar limits imposed by the IRS on employee contributions were $17,500 in both plans, and both plans had the same age 50 and over catch-up provisions that allow older workers to contribute an additional $5,500 per year. Interestingly, public employees are allowed to contribute up to the maximum in both plans. Thus, a state government employee over the age 50 could actually contribute up to a total of $46,000 in combined contributions.[4]

Distributions without tax penalties are allowed at retirement after age 55 in the 401(k), while the 457 plans allow such distributions at termination of employment at any age. This may be an important distinction as many public employees retire from their career state jobs in their early 50s. In-service distributions are allowed prior to age 59½ in 401(k) plans with a 10 percent tax penalty. In-service distributions are not allowed in 457 plans. Thus, workers who wish to maintain the ability to access their fund prior to retirement may be more likely to contribute to 401(k) plans. Both plans allow rollovers to other retirement saving plans or IRAs.

[3] Clark, Pathak, and Pelletier (2017) and Clark, Hanson, Morrill, and Pathak (2016) explore how plan differences affect choices between 401(k) and 457 plans.

[4] These contribution limits have been increased so in 2017, participants can contribute up to $18,000 annual with catch-up contributions of $6,000 allowed for employees over age 50.

Most of the evidence on voluntary retirement saving plans is derived from the analysis of private sector 401(k) plans. These plans are often the only retirement plan offered by firms, so they are actually primary rather than supplemental retirement plans. While many of the same behavioral factors affecting private workers saving decisions in primary 401(k) plans will be relevant to workers considering participation in supplemental plans, individuals covered by a defined benefit plan with access to a supplemental plan may have determined that their retirement savings (pension plus Social Security) to be adequate. Thus, policies advocated for primary plans, such as automatic enrollment and auto-escalation, are likely not appropriate for public employees.

III. Design of the Nudge

The North Carolina Retirement System sent our informational flyers to a randomly selected group among active state employees ages 50-69 with valid email addresses. Individuals were first grouped according to pre-treatment participation status in a supplement plan. The Retirement System selected all workers who had an active account with a balance of more than $1 and year to date contributions of less than $10,000 to form the current participants sample. The current non-participants sample consisted of workers with no current account. Details of the data construction are included below.

A. Current Participants

We developed alternative versions of an informative flyer aimed at increasing contributions to the supplemental retirement saving plans. The participant group was randomized into a control group and three treatment groups (Baseline, Longevity, and Tax Advantage). The control group received no nudge. Figure 1 displays the informational nudges that were sent to those in the treated participants group. The baseline group received a nudge

with general information about the supplemental saving plans, including a direct link to the plan provider's website to facilitate activity. The baseline nudge also provided information on catch-up provisions, which raise yearly contribution limits for individuals ages 50 and older. Note that all employees in our sample population qualify for this benefit. Given our focus on older workers, information about these catch-up provisions was a key part of the design.

[Figure 1]

The longevity and tax advantage group received the baseline nudge plus additional information that had a specific target. Figure 1 illustrates the additional text within a red box. The longevity nudge was a negative framing and included information on average life expectancy when retiring at age 65 and the need to save to offset any future out-of-pocket medical expenses. The tax advantage nudge was a more positive framing by emphasizing the tax-advantaged nature of supplement saving plan contributions. The tax advantages of saving for retirement through supplemental saving plans are frequently discussed among economists and financial advisors but it is unclear how widely understood this information is for a typical individual in the population (Lusardi and Mitchell, 2014).

B. Current Non-participants

The non-participant group was randomized into a control group and four treatment groups (Baseline, Longevity, Liquidity, and GoalMaker). Figure 2 displays the informational nudges that were sent to treated non-participants. As with participants, the control group received no nudge. The baseline group received a flyer including a direct link to open an account and emphasizing catch-up provisions. Similar to the participants group, the longevity group received the baseline nudge with additional information targeted toward extended time spent in retirement. The liquidity group received the baseline nudge with additional information

emphasizing the availability of supplemental plan withdrawals for older workers prior to retirement.[5] Finally, the GoalMaker group received the baseline nudge with additional information about the ease of personalizing investment decisions through a risk tailoring feature known as GoalMaker.[6] GoalMaker allows individuals to select a specific risk profile for their investments by answering a series of straightforward questions, thereby avoiding choice overload or a reliance on financial sophistication. GoalMaker automatically alters the investments in the saving account to fit the risk profile selected by the participant. The objective of this nudge was to reduce the concerns of individuals who doubted their ability to manage investment accounts about participating in a retirement saving plan.

[Figure 2]

C. Data

The North Carolina Retirement System developed a sample of 14,710 active workers at NC state agencies, ages 50-69 as of November 2014.[7] The sample includes individuals enrolled in the Teachers' and State Employees' Retirement System (TSERS) who have never previously retired or claimed long-term disability and have an email address available on record.[8] The

[5] Note that only non-participants received a nudge emphasizing the ability to take in-service distributions out of concern that we might nudge withdrawals from those who already have supplemental retirement savings in the state-managed plans.

[6] A description of GoalMaker is provided by Prudential at: http://www.retire.prudential.com/media/managed/iratoolkit.pdf, [accessed July 10, 2017].

[7] More information about the data is provided in Appendix A.

[8] Teachers and other school personnel are excluded from this study because all North Carolina school districts also offer employees the opportunity to invest in 403(b) plans and in some cases, locally-

sample excludes individuals with an active account with an account balance below $1 or year to date contributions exceeding $10,000. In addition, the sample excludes individuals with outstanding loans, suspended accounts, or those who received employer contributions in 2014.

The Retirement System provided us with administrative data on all sample individuals at three points: October 31, 2014, December 31, 2014, and August 15, 2015. The administrative records allow us to construct data on whether the individual has an active account and, if so, what type of plan, balance in each plan, and year-to-date contributions in each plan.[9] We supplement these cross-sectional data with longitudinal data from October 1 – December 31, 2014, which includes observations on account openings and contribution changes (increases or decreases) and the exact date the change was made. For those who made a contribution change, we observe the original contribution level and the new contribution level.[10] Finally, for all individuals, we observe years of service, salary, state agency of employment, age, and gender. We also utilize survey data in Section VII, described in more detail in Appendix C.

Table 1 presents characteristics of employees in our full data and then separately for current participants and current non-participants. Column (4) presents p-values of the differences between participants and non-participants. Throughout, we use nonparametric tests

managed 457 plans. We do not have access to the contributions and account balances in any locally-managed plans that are widely used by teachers. Thus, these individuals were deleted from the sample.

[9] Appendix A provides detail on how these terms are defined in our data.

[10] Plan participants may elect to make contributions of a given amount or at a given rate (percent of salary). Using salary information, we convert rate contributions to amounts. There are a small number of individuals with missing salary information (as shown in Table 1). For these individuals, we convert rate contributions to amounts using mean salary but the results are robust to dropping all individuals with missing salary or all individuals with missing salary who made contribution changes.

for consistency with the experimental economics literature; discrete variables are tested using a difference in proportions test, while continuous variables are tested using a difference in medians test. In all analysis, we summarize continuous outcomes using medians. About 44 percent of the sample is male, and men are no more likely to be participants than women. Even though the sample is restricted to those ages 50 and older, the median age of non-participants is about one year older. More importantly, we impute age at hire for individuals and observe that the median age of non-participants, 45 years old, is about 5 years older than participants. This suggests that non-participants may be more likely to have worked prior to state agency employment and may have outside retirement savings (e.g., a 401(k) plan from prior employer). We do not have data on individuals' access to or participation in supplemental plans outside of the state-managed supplemental retirement saving plans.

We observe that non-participants have a lower median salary than participants, which is consistent with those with lower earnings having higher replacement rates from Social Security thus indicating a lower need for additional retirement savings (Biggs 2017). Individuals with lower annual earnings also may have less ability to save given demands for current consumption. We also observe that the median years of service for participants is 18 relative to only 12 for non-participants. Given the similarity in median age, the difference in years of service between the groups is likely due to age at hire (as noted above).

[Table 1]

D. Validity of Experimental Design

The retirement system sent email nudges containing information on supplemental saving plans over a three day period: Wednesday, November 12 through Friday, November 14, 2014.[11] To demonstrate the validity of randomization, Table 2 presents summary statistics for individuals in the treatment and control groups separately for participants and non-participants. In Panel A, the treatment-to-control demographic differences are statistically insignificantly different for both participants and non-participants. Panel B shows various measures of savings behavior for participants. Individuals in the treatment group are three percentage points more (less) likely to be participating in both a 401(k) plan and a 457 plan (a 401(k) plan only); a similar proportion of treated and untreated individuals participate in 457 plans. While the split among the treatment and control groups across plan types is statistical significantly different, we do not distinguish between plan types in the regression analysis that follows.

[Table 2]

More importantly, the pre-treatment plan balance of the treatment and control groups are very similar. The median total balance is $16,363 for the treatment group and $16,368 for the control group. For year-to-date contributions, the median contribution through October 31, 2014 is $1,000 for both the treatment and controls groups. Despite having the same medians, the p-value from a medians test suggests a statistically significant difference between year-to-date

[11] The flyers were distributed by the Retirement Systems Division (RSD) at the North Carolina Department of State Treasurer (DST). To avoid an excessive increase in call volume in the supplemental plan administrator's call center, the distribution of flyers was staggered over the course of three days (November 12, 13, and 14, 2014). To reduce the load on email servers, two waves were distributed each day (8:00 AM and 8:05 AM).

contributions (i.e., slightly more treated individuals have an above-median year-to-date contribution relative to control individuals).[12] Given that these differences are small (again, the medians are exactly the same), we conclude that this is not a large concern.

As a further demonstration of pre-nudge similarity between the treatment and control groups, we graphically present daily rates of contribution increases for those with a non-zero balance as of October 31, 2014 (i.e., the participant sample). A local polynomial regression fitted curve is overlaid.[13] Figure 3 illustrates these values for the month of October, which is prior to the nudge but also includes the open enrollment period. In Figure 3, we see treatment and control groups have similar patterns of contributions.

[Figure 3]

The daily rates of contribution increases are small, where the average day in October saw 0.2 percent (i.e., two-tenths of one percent) of the sample increase their contribution. It is not surprising that, on a randomly chosen day of the year, few individuals log into their supplemental saving plan provider's website to change their contribution. Further, note that October is the annual enrollment month for public sector employees to make elections for the State Health Plan

[12] A two-sample medians test asks whether one group has a statistically dissimilar proportion of individuals for whom the variable takes a value above the median. When there is a mass point in the distribution at the median, "median ties" can confuse the interpretation of the test. For the treatment group, 48.51% of Total YTD Contributions are below $1,000, 7.83% are equal to $1,000, and 43.66% are above $1,000. For the control group, the percentages are 49.13%, 9.87%, and 41.00%. The distribution of YTD Contributions is shown in Appendix Figure B1. This figure is consistent with the validity of randomization for this variable.

[13] A local polynomial regression is a nonparametric technique for flexibly modeling associations between two variables. Figures 3 and 4 use a bandwidth of seven days. Beyond the daily rates of contribution increases in Figures 3 and 4, Appendix Figures B2 and B3 present daily rates of contribution changes.

in North Carolina. We were aware of the focal nature of October for a number of employee-benefit-related decisions, including obviously the health plan but also decisions regarding retirement savings. The timing of our nudge reflected a desire to avoid the annual enrollment month, worrying that the increased level of underlying activity in October would make precise estimates more difficult to obtain. The fitted curves for both the treatment and control groups present an intuitive pattern: slightly more activity at the beginning of October (when open enrollment begins) and at the end of October (just before open enrollment closes), relative to the middle of the month. There are no apparent treatment-control differences in the month prior to the nudge.

Figure 4 presents these daily rates for the month of November. The vertical line is the first date that a flyer was sent. Prior to November 12, we again see that treatment and control experienced similar contribution rate increases. We also observe that the average daily rate of contribution increases between November 1 and November 9 was around 0.1 percent. It is important to keep this scale in mind when interpreting the treatment effects that are discussed in the next section. The effect of the receiving the nudge is clearly shown to the right of the vertical lines in Figure 4. Contribution increases are strikingly higher in the treatment group as compared to the control group and the effect is concentrated just after the nudge was sent.

[Figure 4]

Figure 3 and the left panel of Figure 4, along with results in Table 2, demonstrate the validity of the experiment design and the similarity of the treatment and control groups. We proceed with analysis of treatment relative to control using post-nudge data only, consistent with our setting of a randomized controlled trial.

IV. Treatment Effects of the Informational Intervention

A. Aggregate Results for Participants

The right panel of Figure 4 previews the main result that, among participants, the nudge was associated with more contribution increases in the treatment group relative to the control group. To get a better sense of magnitudes, Table 3 shows the rates of contribution increases and decreases. Here, the post-nudge period is defined as following the receipt of the email through December 31, 2014.[14] In all treatment columns, we test statistical significance relative to the control group using a difference in proportions test.

[Table 3]

The treatment group increases its contributions at a rate of 2.8 percent, cumulatively over the late November/December period. This is statistically significantly higher than the 1.8 percent rate for the control group, for a treatment effect of 1.0 percentage points. The treatment group also decreases contributions at a higher rate, 1.1 percent versus 1.0 percent, but this difference is not statistically significant. Interpreting these results requires additional information about individual's preferences and financial state. If we adopt a presumption that individuals are undersaving, then the appropriate metric for the effect of the nudge is the rate of contribution increases minus the rate of contribution decreases. If we instead rely on revealed preferences, the appropriate metric is the rate of contribution changes.

[14] That is, the activity of an individual in the treatment group is included in this analysis beginning of the day she received the nudge (either November 12, 13, or 14). For the control group, the control period starts November 12, which is conservative in the sense that any activity in the control group during any nudge send day is included for the control group, potentially increasing the control rate that we are netting out.

Our approach to the ambiguity in interpreting the results of policy interventions is to present a full picture of individuals' actions following the nudge. Table 3 thus shows the rate at which individuals made any change to their contribution rate.[15] This includes all activity including changes that left one's contribution rate identical to the pre-treatment rate (e.g., rate increase of $1,000, followed by a rate decrease of $1,000). Treated individuals were statistically significantly more like to make net contribution changes at a rate of 3.8 versus 2.8 percent. Similarly, 3.9 percent of treated individuals made any change in contribution relative to only 2.8 percent of those in the control group.

Next, we exploit the detailed nature of our data by following individuals through August 15, 2015, which is nine months after the nudge. We refer to this time period as medium-term actions. The outcomes of interest are similar as before, except that we can only observe net contribution changes because the cross-sectional data we have from August 15, 2015 do not allow us to construct a panel of contribution changes. Not surprisingly, we observe much higher rates of activity overall in the medium-term. The control group increased contributions at a rate of 15.5 percent and made net changes at a rate of 22.7 percent. For treated individuals across all treatments, all rates are higher. The treatment effects are 2.1 percentage points for contribution increases and 3.6 percentage points for contribution changes. Each of these effects is statistically significant. The outcome of the nudge is meaningful for participants, irrespective of our perspective for the appropriate metric for interpreting the results (presumption of undersaving or revealed preferences).

[15] It should be noted that we do not observe one-time contributions, so all results will understate the total behavioral response to the nudge.

Finally, Panel B of Table 3 presents the effect on balances or contribution changes in dollars, conditional on making a medium-term net contribution change. Conditional on making a change, balance and contribution changes are similar across treatment and control groups. Thus, our nudge moved some participants into changing their contribution rates but did not lead to larger contribution levels among those who made changes.

The means reported in Table 3 suggest that the tax advantage treatment led to more contribution increases than either the baseline or longevity treatments. As we will show below, the differences between treatments are not statistically significant in most cases. Still, we observe that the longevity treatment was associated with the smallest movements in contribution increases, decreases, or changes, relative to the other treatments. The tax advantage treatment was designed to emphasize the tax-favored nature of contributions to supplemental saving plans. This is one of the typical framings for retirement savings interventions. The longevity treatment was designed with our sample of older workers specifically in mind, where we highlighted the life expectancy of the typical retiree in our sample. The results in Table 3 suggest that, in our sample, a negative framing (reminding individuals that they may grow very old and sick) did not outperform a positive framing (reminding individuals that contributions lower their tax bill). We return to this discussion in Table 5 below.

We conclude that the nudge prompted some current participants to increase the amount they contribute to their supplemental saving plan and others to change their contributions in the opposite direction. In the discussion that follows, we continue to present results for both contribution increases and contribution changes to allow an understanding of the effect of this nudge without relying on a presumption that individuals are undersaving.

B. Regression Results

In a randomized controlled trial, we expect that including covariates will not meaningfully affect the treatment effect found in the pairwise comparisons of the previous section. This is exactly what we see in Table 4. Here, we provide estimates of average marginal effects from a Probit model regression with four outcomes as defined in Table 3 above: short-term increase, short-term any change, medium-term increase, and medium-term net change. As found in Table 3, when no controls are included the effect of the treatment is a one percentage point increase in the probability of increasing contributions. Column (2) includes a host of individual controls available in the administrative records.[16] Overall, men are more likely to increase contributions, as are those with lower salaries and higher initial balances. As expected, the estimated effect of the nudge is unchanged by adding these control variables. Column (3) again shows an identical point estimate.

[Table 4]

Next, Table 4 presents results for an alternative dependent variable: making any change in contributions after the nudge and before December 31, 2014. The estimated impact of the nudge is 1.2 percentage points. Adding controls again yields similar estimates. Receiving the nudge is associated with a 1.1 percentage point higher probability of making any change to supplemental retirement saving plan contributions. Columns (5)-(6) indicate that receiving the nudge led to a 2 percentage point higher probability of increasing contributions over the subsequent nine months.

[16] Agency fixed effects are grouped into five categories. We group the smaller agencies into two categories: agencies as those with fewer than 100 employees in our sample and those with between 100 and 1,000 employees in our sample. The three largest agencies have separate controls: Department of Health and Human Services, Department of Public Safety, and Highway Administration. Relative to the small agencies, employees at Health and Human Services and the Highway Administration were about 1 percentage points less likely to have a net increase in contributions.

This is off of a mean contribution rate of 17 percent, so represents about 12 percent of the mean. Similarly, when considering whether the employee made a net change in contributions (either an increase or decrease), we see that the nudge increased the likelihood of making a net change by 3.6 percentage points off of a sample mean of 25.4 percent (about 14 percent of the mean). Thus, even among a group where contribution changes are relatively rare, our informational nudge did change behavior by an economically and statistically significant amount.

C. Heterogeneity in Treatment Effects

Table 5 considers heterogeneity in the effects of the treatment for short-term and medium-term contribution increases in Panels A and B, respectively. Results for any change or net change are similar and are presented in Appendix B. The regression specifications are parallel to Table 4, Columns (2) and (6), respectively, but include interaction terms with the treatment variable. In Panel A, Column (1), the differential effect of receiving the longevity or tax advantage treatment relative to the baseline treatment is not statistically significant. Thus, we find that a more detailed nudge is no more influential than the baseline in increasing contributions. Interestingly, in Panel B, we observe that the baseline treatment and longevity treatment did not result in a statistically significant probability of increasing contributions and the full result in the medium-term is concentrated among those receiving the tax treatment.[17]

[Table 5]

Next, we consider whether the nudge was disproportionally effective for different demographic groups. In Column (2) of Table 5, we see that the effect of the nudge was

[17] Separately comparing each of the more detailed treatments to the control group, we find statistically significant treatment effects with contribution increases for both (longevity: estimate = 0.6 percentage points, p-value = 0.05; tax advantage: estimate = 1.3 percentage points, p-value = 0.01).

concentrated among men with no statistically significant difference between treatment and control for women. We find no statistically significant differences by salary level or years until eligible for retirement benefits. The treatment effect is concentrated among those with below median age at hire. This is consistent with lower overall participation rates among those with older ages at hire shown in Table 1. One interpretation is that older-at-hire individuals are entering public sector employment after other employment spells, possibly coming from the private sector. Those with fewer years of service were also more likely to respond to the treatment, although that difference is only statistically significant in the medium-term.

Finally, in Columns (7) and (8) of Table 5, we see that the short-term treatment effect is only statistically significant for those with above median initial balance in the plan. The median initial plan balance is $16,363. However, the effect is not concentrated on those with the very highest initial plan balances and the difference is not statistically significant in the medium-term. The 90th percentile of initial plan balance is $97,676. Those with initially low balances were not induced to save more by the nudge. This is consistent with the results discussed next for those who had no supplemental retirement savings through the state-managed plans.

V. Non-participants

Table 6 presents the results for non-participants. These are individuals who have had numerous opportunities to begin saving additional funds in their state-government employer-sponsored supplemental saving plans. As emphasized in the introduction, our non-participant sample may consistent of individuals with a preference for current consumption over saving for additional consumption in retirement. These individuals are covered by both a defined-benefit pension plans and Social Security. Further, some individuals in our non-participant sample may

in fact be participating in a supplemental saving plan, perhaps through a previous employer or a spouse's employer.

[Table 6]

For non-participants, we show the results in terms of the same outcomes as before. However, with non-participants, increasing their contribution either requires that they restart contributing to an inactive plan or open a new plan and begin contribution. The effect sizes in every cell in Table 6 are quite small, with 0.6 percent (i.e., six-tenths of one percent) of the control group increasing their contribution from the nudge until the end of 2014. This is statistically insignificantly larger than the rate for the treatment group. The same pattern holds for all outcomes in Table 6: small rates of activity for non-participants with no evidence of a positive treatment effect.

Concerning specific treatment types, the longevity treatment repeats the treatment used for participants. As before, the longevity treatment effect is slightly smaller than the baseline treatment effect but the difference is not statistically significant. The liquidity treatment emphasized the availability of supplemental plan withdrawals for older workers prior to retirement. The GoalMaker treatment emphasized the ease of personalizing investment decisions through a risk tailoring feature known as GoalMaker, as described in Section III.B. The liquidity and GoalMaker treatment effects are smaller than the baseline treatment effect but the differences are very small. For all outcomes, we conclude that the rates of activity in the non-participant group are so small that we cannot draw any conclusions beyond the fact that our nudge did not significantly affect saving behavior for non-participants.

VI. Longer-term outcomes

Our final analysis uses survey responses from a subset of our nudge sample. More detail on these data is provided in Appendix C. This field experiment was part of a larger project that included a series of surveys of North Carolina public sector workers. We now link individuals in our nudge sample to respondents to these surveys. It is important to emphasize that the flyers in our nudge were sent by the NC Retirement Systems Division, while the survey invitations were sent by us from a university email address. As a result, from the perspective of survey respondents, the overlap between the nudge and the surveys was likely to be opaque. This implies that survey respondents are unlikely to have been thinking specifically about the flyer received about six months earlier as they responded to our survey. Consistent with this claim, we find that retirement rates and survey response rates are statistically insignificantly different for individuals in the nudge sample between the treatment and control group. Results are presented in Appendix C. For this portion of the analysis, we restrict our attention to the individuals that were actively employed as of April 2016, who responded to our survey, and who were in either the treatment or control group for the experiment. The sample sizes are 318 respondents for the participant group and 341 respondents for the non-participant group. Recall that participation status is determined by the pre-treatment status and that different flyers were sent to each group.

Table 7 presents a series of regression analyses for individuals' survey responses among those who were included in our 2014 nudge sample and responded to our survey, which was fielded from May 2016 to July 2016. Columns (1) and (2) include individuals in our nudge participant sample, while Columns (3) and (4) include individuals in our nudge non-participant sample. First, we replicate the analysis from Table 4, Columns (5) – (8) on medium-term

outcomes looking only at this smaller sample. Here, we do not have power to detect any treatment effect on contribution increases.

[Table 7]

Next, in Table 7, Panel C, we consider whether an individual reports having a retirement plan.[18] The statements in Panels D and E are measures of perceived retirement readiness. Panel D presents results where the dependent variable is an indicator for agreeing with the statement: I believe I will have enough money to live comfortably throughout retirement. Similarly, Panel E presents estimates for agreeing with the statement: I believe I am saving the right amount for retirement. Full text of the question wording is presented in Appendix C. We find that having received an informational flyer on supplemental plans in 2014 is associated with large increases in retirement planning and perceived retirement readiness, as self-reported in 2016. Unincentivized survey responses can be criticized relative to objectively measured outcomes. But this self-reported information provides useful insights into how individuals perceive their financial situation and as such, complements the outcomes that are observed in the administrative data.

Columns (1) and (3) show the mean differences among treated and control individuals, while Columns (2) and (4) add the same individual-level controls as measured in the administrative data. For participants, individuals in the nudge treatment group report having a retirement plan at a rate that is around 12 percentage points higher than the rate for those in the nudge control group. When controls are added, the treatment effect falls to 10.5 percentage points, which remains statistically significant. The two measures of perceived retirement

[18] For a detailed discussion of the importance of retirement planning and factors associated with making a retirement plan, see Clark, et al. (2017).

readiness provide effect sizes that are relatively similar but the standard errors are quite large. Treated individual are 11.3 percentage points more likely to report expecting to have enough money for retirement but the standard error of the difference is 7.8 percentage points. Treated individuals are 8.6 percentage points more likely to report that they are saving the right amount for retirement (standard error of 5.3 percentage points). We interpret this as suggestive evidence that the nudge led to increases in retirement planning and perceived confidence in retirement readiness. But given the small sample size and the associated noise in our estimates, we cannot definitively conclude that the nudge had long-term positive effects.

For non-participants, there is no evidence that the nudge led individuals to change their saving or planning behavior along any dimension. For non-participants, individuals in the treatment group are 6.5 less likely to report having a retirement plan, 2.8 percentage points more likely to report confidence in retirement savings, and 1.1 percentage points more likely to report confidence in retirement savings. Each of these coefficients is smaller than its associated standard error. Thus, the nudge also had no effect on planning or perceived retirement readiness for those that were not participating in the NC 401(k) or NC 457 plan prior to the nudge.

VII. Conclusion

Policy interventions aimed at encouraging retirement saving typically emphasize the importance of compounding. This framing may be discouraging to workers late in their career who have fewer working years for account balances to meaningfully benefit from compounding. However, there are several advantages to retirement saving that benefit older workers. Retirement savings are more liquid for older workers because in-service withdrawals are allowed for workers over age 59 ½ from 401(k) plans. Further, catch-up provisions allow older workers, many who are on the verge of retirement, to save additional funds above the regular IRS

maximum contribution limits. Thus, while older workers may be harder to encourage to save, they have several reasons to take advantage of supplemental retirement saving plans.

For workers covered by a primary defined benefit pension plan and Social Security, an individual's retirement income may be adequate without supplemental savings. Further, workers hired at older ages may have other sources of retirement savings and thus may elect not to participate in a new employer's sponsored plan. In total, interventions that target supplemental saving plan participation should keep in mind the tradeoff between financial security in retirement and financial security during working years. We interpret the results of our policy intervention while trying to avoid paternalistic presumptions of welfare enhancing behavior at the individual level (Bernheim and Rangel, 2005).

In this study, we sent an informational nudge to a randomly selected subset of older state government employees in North Carolina. The group receiving the flyers was about 2 percentage points more likely to increase contributions in the 9 months following the receipt of the flyer than the control group who received no flyer, representing about 12 percent of the sample mean. We also find that some individuals reassessed their retirement savings and chose to decrease contributions. When considering net changes, we find that the treatment led to a 3.6 percentage point higher probability of making a net change within 9 months relative to the control group (about 14 percent relative to the sample mean of 25.4 percent).

We take advantage of the extensive nature of our data by linking individuals in our nudge sample to a detailed survey that was conducted nearly two years later. For individuals in the nudge sample who subsequently responded to our survey, we find additional evidence that the nudge affected behavior. Among those who were already participating in a state-managed retirement saving plan prior to the nudge, receiving a flyer increased the probability of having

made a retirement plan and increased self-reported confidence in retirement income security. These results suggest that our intervention led individuals to reassess their retirement savings decisions. While a low cost informational nudge might not cause large fractions of older workers to substantially increase their contribution rates to supplemental plans, such interventions may encourage retirement planning. This represents an important dimension along which to measure the success of retirement savings inventions.

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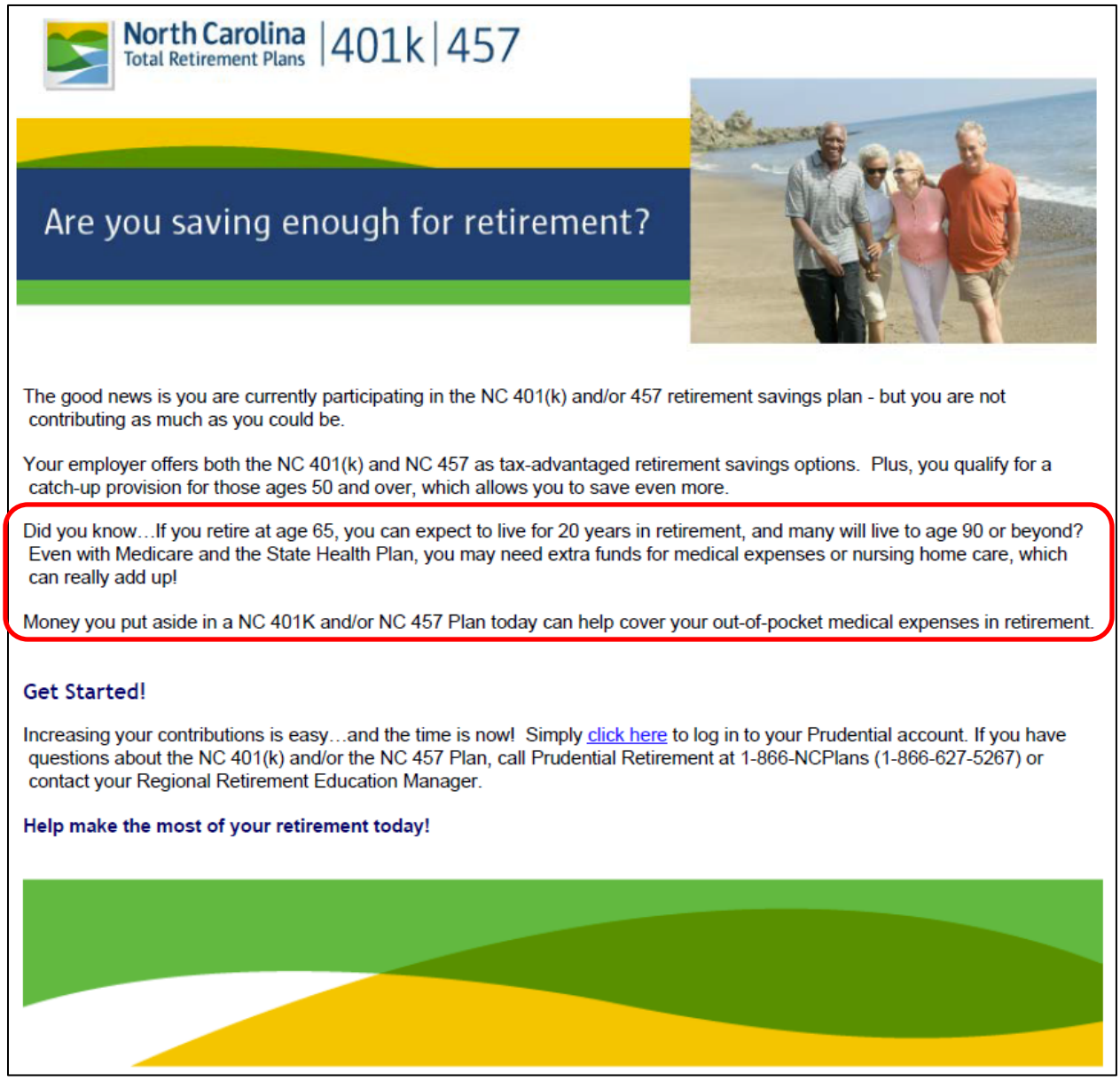
Figure 1: Informational Flyer Design for Current Participants

A. Current Participants - Longevity



B. Current Participants - Tax Advantage

Did you know…Pre-tax contributions to the NC 401(k) and NC 457 are automatically deducted from your paycheck before any federal or state income taxes are taken out, therefore, reducing your taxable income? This means that saving $400 per month for retirement is really only about $300 out of your monthly take-home pay.* Additionally, these contributions grow tax-deferred until withdrawal. This can really mean more money for you in retirement.

*Reduction in take-home pay is based on a marginal tax rate of 25%. Your tax savings may be higher or lower.

Figure 2: Informational Flyer Design for Current Non-participants

A. Current Non-participants – Liquidity

B. Current Non-participants – GoalMaker

How do you like to save? The NC 401(k) and NC 457 offer a range of investment vehicles from high growth to highly conservative, so you can make the most appropriate choice to meet your savings goals. Still not sure? Let GoalMaker® help! It's an optional, easy-to-use asset allocation program available at no additional cost that automatically guides you to an age-appropriate investment mix based on your risk tolerance and the time you want to begin withdrawing money.* Let GoalMaker do the work for you, or personalize your NC 401(k)/NC 457 investment choices to fit *your* approach to saving for retirement!

*Investment of your account balance according to a GoalMaker portfolio can, and will, be canceled at any time if you direct Prudential to invest your account according to an investment allocation of your own design. The GoalMaker portfolios are subject to change, including, for example, the replacement of investment options and the change of investment options as a percentage of the portfolio. You will be notified in writing in advance of any such changes. Application of asset allocation and diversification concepts does not ensure safety of principal and interest. It is possible to lose money by investing in securities.

C. Current Non-participants – Longevity

Did you know…If you retire at age 65, you can expect to live for 20 years in retirement, and many will live to age 90 or beyond? Even with Medicare and the State Health Plan, you may need extra funds for medical expenses or nursing home care, which can really add up! Money you put aside in a NC 401K and/orNC 457 Plan today can help cover your out-of-pocket medical expenses in retirement.

Figure 3: Contribution Increases, Daily, Pre-Nudge, October

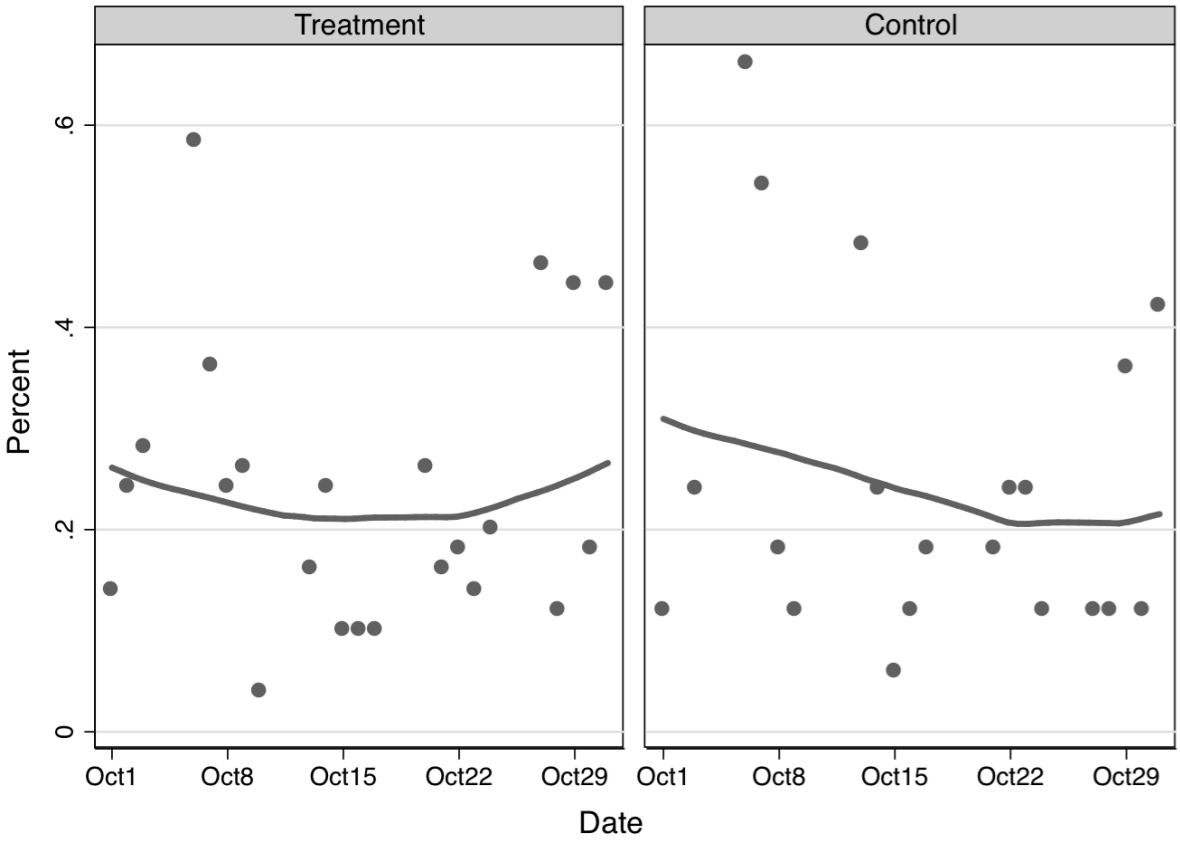


Figure 4: Contribution Increases, Daily, Pre-and Post-Nudge, November

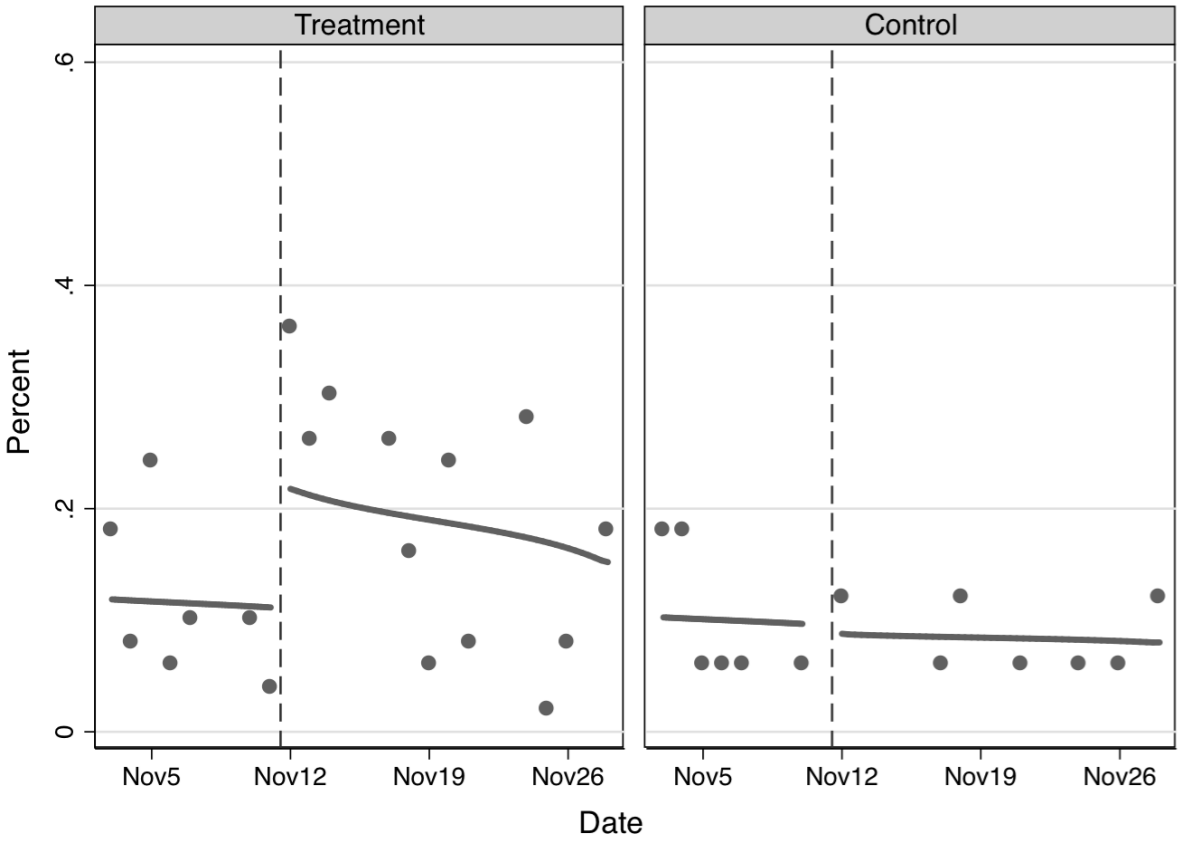


Table 1: Descriptive Statistics

	Nudge Sample	Participant Sample	Non-Participant Sample	p-value of difference
	(1)	(2)	(3)	(4) = (3)-(2)
Number of Employees	14,710	6,629	8,081	
Male	44.1%	44.1%	44.0%	0.85
Age	57.1	56.4	57.6	0.00
Age at hire	42.7	39.8	44.9	0.00
Salary	$43837	$47,204	$41,603	0.00
Missing salary	2.1%	1.7%	2.4%	0.00
Years of service	14.8	18.0	12.1	0.00
Eligible to retire	53.4%	59.2%	48.7%	0.00
Years until eligible to retire	0.0	0.0	0.2	0.00

Notes: Data are derived from administrative records of public sector workers in North Carolina as of October 31, 2014. Medians of continuous variables and percentages of dichotomous variables are presented. Participants are those with a positive account balance in supplemental saving plans as of October 31, 2014 while non-participants are those with zero balance and zero contributions. Statistical significance is tested with nonparametric tests: discrete variables are tested using a difference in proportions test, while continuous variables are tested using a difference in medians test.

Table 2: Experimental Design

	Participants (N=6,629)			Non-participants (N=8,081)		
	Control (N=1,661)	Treatment (N=4,968)	p-value	Control (N=1,625)	Treatment (N=6,456)	p-value
Panel A: Demographics						
Male	44.3%	44.1%	0.92	43.8%	44.1%	0.71
Age	56.6	56.4	0.26	57.5	57.6	0.78
Age at hire	39.7	39.8	0.91	44.8	44.9	0.78
Salary	$47,490	$47,149	0.82	$41,966	$41,492	0.26
Missing salary	1.4%	1.8%	0.40	2.2%	2.5%	0.47
Years of service	17.8	18.1	0.65	12.3	12.0	0.56
Eligible to retire	58.4%	59.5%	0.44	47.0%	49.1%	0.13
Years until eligible to retire	0.0	0.0	0.44	0.5	0.1	0.15
Panel B: Measures of saving behavior						
Participation in 401(k) only	51.2%	47.7%	0.01			
Participation in 457 only	28.4%	29.1%	0.55			
Participation in both 401(k) and 457	20.4%	23.2%	0.02			
Total initial balance	$16,368	$16,363	0.98			
Total YTD contribution	$1,000	$1,000	0.06			

Notes: Data are derived from administrative records of public sector workers in North Carolina as of October 31, 2014. Medians of continuous variables and percentages of dichotomous variables are presented. Participants are those with a positive account balance in supplemental saving plans as of October 31, 2014 while non-participants are those with zero balance and zero contributions.

Table 3: Current Participant Sample Post-Nudge Actions

	Control	All Treatments	Baseline Treatment	Longevity Treatment	Tax Advantage Treatment
	(1)	(2)	(3)	(4)	(5)
Panel A: Full sample					
Sample size	**1,661**	**4,968**	**1,656**	**1,656**	**1,656**
Actions as of December 31, 2014:					
Increased contributions short-term	1.806%	2.758	2.717	2.355	3.200
		(0.444)*	(0.516)+	(0.496)	(0.542)*
Decreased contributions short-term	0.963%	1.087	1.449	1.027	0.785
		(0.290)	(0.379)	(0.345)	(0.323)
Made any changes to contributions short-term	2.830%	3.986	4.287	3.442	4.227
		(0.535)*	(0.643)*	(0.605)	(0.641)*
Actions as of August 15, 2015:					
Increased contribution medium-term	15.473%	17.552	17.271	16.486	18.901
		(1.065)+	(1.285)	(1.272)	(1.310)**
Made net changes to contribution medium-term	22.697%	26.248	25.725	25.242	27.778
		(1.233)**	(1.487)*	(1.482)+	(1.508)**
Panel B: Sample making a medium-term net change					
Sample size	**346**	**1,189**	**381**	**387**	**421**
Balance change conditional on changing	$1,672.31	$1,646.07	$1,587.85	$1,566.12	$1,793.78
		(0.90)	(0.88)	(0.66)	(0.72)
Contribution change conditional on changing	$120.00	$120.00	$191.61	$108.62	$163.49
		(0.86)	(0.60)	(0.77)	(0.83)

Notes: Stars indicate that the proportion of individuals in that group taking the specified action is statistically significantly different than the proportion of individuals in the control group taking the same action. An increase or decrease in contribution refers to contribution having increased or decreased as of December 31st, 2014 (short-term) or August 15, 2015 (medium-term), compared to that as of October 31st, 2014. A medians test is used for balance change and contribution change and the p-value is reported in parentheses, + $p<0.1$, * $p<0.05$, ** $p<0.01$.

Table 4: Multivariate Regression Analysis of Participant Response

	Short-Term Increase		Short-Term Any Change		Medium-Term Increase		Medium-Term Net Change	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.010**	0.009**	0.012**	0.011**	0.021*	0.020+	0.036**	0.036**
	(0.002)	(0.002)	(0.003)	(0.003)	(0.010)	(0.010)	(0.012)	(0.012)
Male		0.007*		0.009*		0.000		0.010
		(0.003)		(0.004)		(0.009)		(0.013)
Age		-0.000		0.001+		-0.004**		0.006**
		(0.001)		(0.001)		(0.001)		(0.002)
Salary ($1K)		-0.002*		-0.002*		0.003		0.004+
		(0.001)		(0.001)		(0.003)		(0.002)
Missing salary		0.003		0.011		0.441**		0.432**
		(0.006)		(0.016)		(0.053)		(0.036)
Years of service		-0.001*		-0.001*		-0.007**		-0.005*
		(0.000)		(0.000)		(0.002)		(0.002)
Eligible to retire		-0.004		-0.002		0.003		0.045+
		(0.004)		(0.006)		(0.014)		(0.023)
Years until eligible to retire		-0.000		0.002		-0.001		0.013**
		(0.002)		(0.002)		(0.004)		(0.005)
Initial balance ($1K)		0.003**		0.004**		0.006*		0.006**
		(0.001)		(0.001)		(0.002)		(0.002)
Initial balance ($1K)^2		-0.000*		-0.000**		-0.000		-0.000
		(0.000)		(0.000)		(0.000)		(0.000)
Agency FE		X		X		X		X

Notes: N = 6,629. Coefficients are average marginal effects from a Probit model. In Columns (1) and (2), the dependent variable is whether the individual had a net increase in contributions between October 31, 2014 and December 31, 2014 with mean 0.025. In Columns (3) and (4), the dependent variable is whether the individual made any change in contributions (increase, decrease, or both) between October 31, 2014 and December 31, 2014 with mean 0.037. In Columns (5) and (6), the dependent variable is whether the individual had a net increase in contributions between October 31, 2014 and August 15, 2015 with mean 0.170. In Columns (7) and (8), the dependent variable is whether the individual made a net change in contributions between October 31, 2014 and August 15, 2015 with mean 0.254.Coefficients are marginal effects from a Probit model. Standard errors are in parentheses. Standard errors, clustered by agency, are in parentheses, + p<0.10, * p<0.05, ** p<0.01.

Table 5: Heterogeneity in Treatment Effects

Panel A: Short-Term Increase in Contributions

	Treatment Type	Gender	Salary	Age at Hire	Years of Service	Eligibility	Initial Balance	Initial Balance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All treatments	0.009**	0.004	0.008*	0.015**	0.007+	0.012**	0.001	0.009**
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.005)	(0.003)
x Longevity treatment	-0.004							
	(0.003)							
x Tax advantage treatment	0.003							
	(0.005)							
X Male		0.012						
		(0.008)						
X Salary above median			0.003					
			(0.009)					
X Age at hire above median				-0.013+				
				(0.006)				
X 20+ years of service					0.008			
					(0.009)			
X 5+ years until eligible						-0.013		
						(0.007)		
X Initial balance above median							0.018**	
							(0.007)	
X Initial balance > 90th pctile								-0.005
								(0.014)

Continued on the next page…

Panel B: Medium-Term Increase in Contributions

	Treatment Type (1)	Gender (2)	Salary (3)	Age at Hire (4)	Years of Service (5)	Eligibility (6)	Initial Balance (7)	Initial Balance (8)
All treatments	0.019	0.019	0.025	0.033*	0.033**	0.024+	0.015	0.023*
	(0.013)	(0.013)	(0.016)	(0.015)	(0.011)	(0.012)	(0.012)	(0.009)
x Longevity treatment	-0.011							
	(0.012)							
x Tax advantage treatment	0.016+							
	(0.009)							
X Male		0.004						
		(0.015)						
X Salary above median			-0.009					
			(0.019)					
X Age at hire above median				-0.023				
				(0.015)				
X 20+ years of service					-0.035**			
					(0.013)			
X 5+ years until eligible						-0.018		
						(0.024)		
X Initial balance above median							0.011	
							(0.013)	
X Initial balance > 90th pctile								-0.027
								(0.026)

Notes: N = 6,629. Specifications are identical to Table 4 with controls except with additional interaction terms included as indicated. Coefficients are average marginal effects from a Probit regression model. The dependent variables are Panel A: short-term net increase in contributions and Panel B: medium-term net increase in contributions . Median salary is $47,204; median age at hire is 39.8; median initial balance is $16,363; and 90th percentile of initial balance is $97,676. Standard errors, clustered by agency, are in parentheses, + p<0.10, * p<0.05, ** p<0.01.

Table 6: Current Non-Participant Sample Post-Nudge Actions

	Control	All Treatments	Baseline Treatment	Longevity Treatment	Liquidity Treatment	GoalMaker Treatment
	(1)	(2)	(3)	(4)	(5)	(6)
Sample Size	**1,625**	**6,456**	**1,614**	**1,614**	**1,614**	**1,614**
Actions as of December 31, 2014:						
Increased contributions short-term	0.615%	0.465	0.620	0.372	0.434	0.434
		(0.195)	(0.275)	(0.246)	(0.254)	(0.254)
Decreased contributions short-term	0.062%	0.015	0.000	0.000	0.000	0.062
		(0.044)	(0.062)	(0.062)	(0.062)	(0.087)
Made any changes to contributions short-term	0.677%	0.480	0.620	0.372	0.434	0.496
		(0.200)	(0.282)	(0.254)	(0.261)	(0.268)
Actions as of August 15, 2015:						
Increased contribution medium-term	2.646%	2.525	3.160	2.664	2.540	1.735+
		(0.437)	(0.590)	(0.565)	(0.559)	(0.515)
Made net changes to contribution medium-term	2.769%	2.618	3.160	2.788	2.602	1.921
		(0.446)	(0.596)	(0.578)	(0.568)	(0.532)

Notes: The proportions of individuals in each group taking the specified action are tested for statistical significance relative to the proportion of individuals in the control group taking the same action. A medians test is used for balance change and contribution change and the p-value is reported in brackets. No differences are statistically significant.

Table 7: Longer-term Survey Responses

	Participants (N = 318)		Non-Participants (N = 341)	
	(1) No Controls	(2) Individual Covariates	(3) No Controls	(4) Individual Covariates
Panel A: Net Contribution Increase as of August 2015				
Mean	0.204		0.029	
Treatment	-0.052	-0.043	0.020	0.016
	(0.065)	(0.070)	(0.014)	(0.011)
Panel B: Net Contribution Change as of August 2015				
Mean	0.233		0.029	
Treatment	-0.031	-0.022	0.020	0.016
	(0.063)	(0.066)	(0.014)	(0.011)
Panel C: Made retirement plan				
Mean	0.579		0.449	
Treatment	0.121**	0.105*	-0.057	-0.065
	(0.039)	(0.053)	(0.073)	(0.073)
Panel D: Enough money to live comfortably throughout retirement				
Mean	0.500		0.446	
Treatment	0.119+	0.113	0.009	0.028
	(0.064)	(0.078)	(0.063)	(0.061)
Panel E: Saving the right amount for retirement				
Mean	0.324		0.238	
Treatment	0.089	0.086	0.006	0.011
	(0.054)	(0.053)	(0.057)	(0.055)

Notes: The sample is survey respondents between May and July 20, 2016 who were included in the experiment. The dependent variable is a dummy variable as indicated. Estimates are marginal effects from a Probit regression model. Columns (2) and (4) include the covariates parallel to Table 4. Standard errors, clustered by agency, are in parentheses, + $p<0.1$, * $p<0.05$, ** $p<0.01$.

Appendix A: Data Appendix

The data used in this paper were gathered as part of a larger project, "Challenges to Retirement Readiness in the North Carolina Public Sector Workforce," funded by Sloan Foundation Grant Number 2013-10-20. For more information about the full project, please see the website: http://go.ncsu.edu/publicsectorretirement. Table A1 presents the timeline of the nudge data releases and survey. For this study, the Retirement System provided us with data on 14,710 active workers. All active workers with an email address ages 50 to 69 were eligible for the nudge sample. The sample excludes individuals with year to date contributions exceeding $10,000 and those with account balances less than $1. RSD sent 6,629 and 8,081 informational flyers to the participant and non-participant sample, respectively, and provided us with the contribution data.

Definitions of key variables are presented in Table A2. Of note, there are several types of service that could be important in our analysis. First, there is membership service, which should approximate the actual tenure of the employee minus any transferred or withdrawn service. We use membership service for our measure of job tenure. However, to be eligible for retirement benefits, individuals may also have purchased non-contributory (e.g., sick leave and vacation time) service. These latter types of service are included in our calculation of eligibility for retirement benefits. Because most non-contributory service is only reported upon retirement, we include in these calculations an additional 0.71 years of non-contributory service, which is the mean for the entire population. Years until eligible for retirement are the minimum number of years before an employee can qualify for early or normal retirement when considering all the combinations of age at survey 1 and years of service by which an individual can qualify. If the number of years is less than or equal to zero, the individual already qualifies for retirement.

Table A1: Timeline of data collection

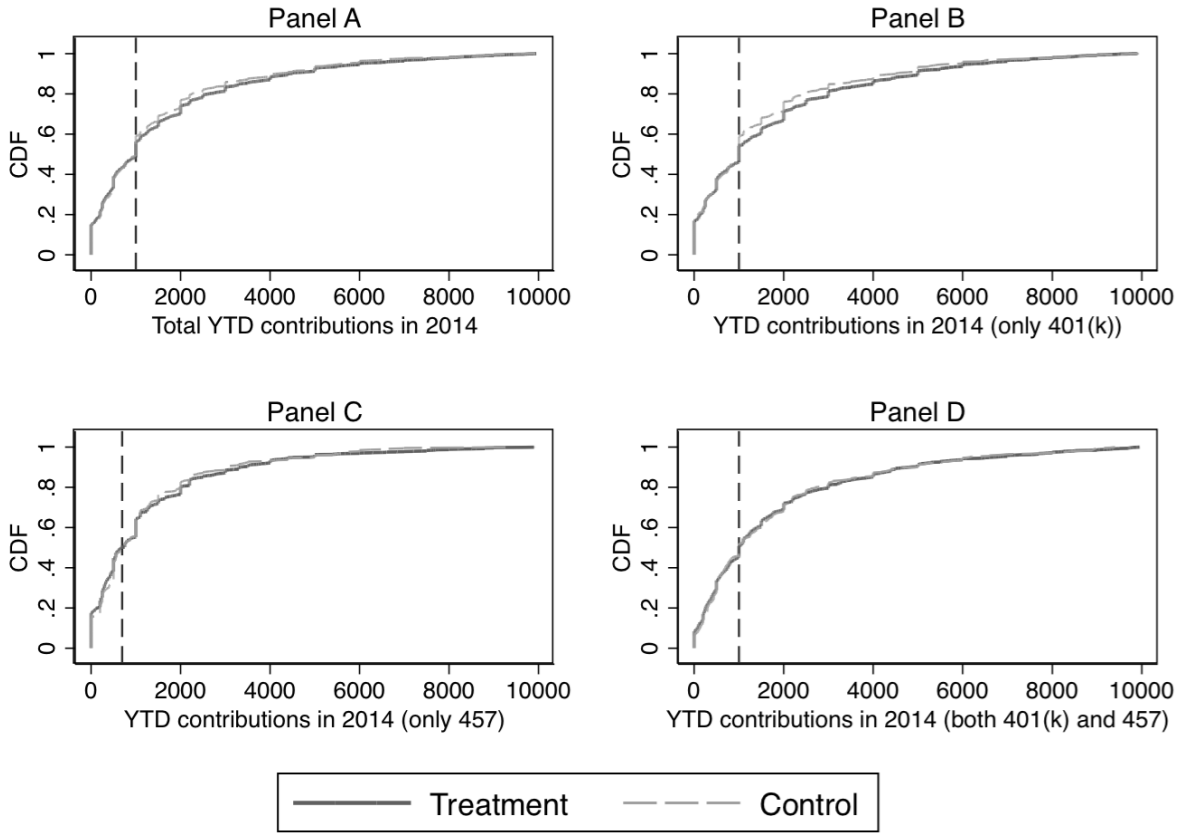
Dataset	Dates
Pre-nudge administrative data	October 31st, 2014
Nudge	November 12th, 2014 - November 14th, 2014
Post-nudge administrative data "short-term"	December 31st, 2014
Post-nudge administrative data "medium-term"	August 15th, 2015
Survey data	May 11th, 2016 - July 20th, 2016

Table A2: Key variables

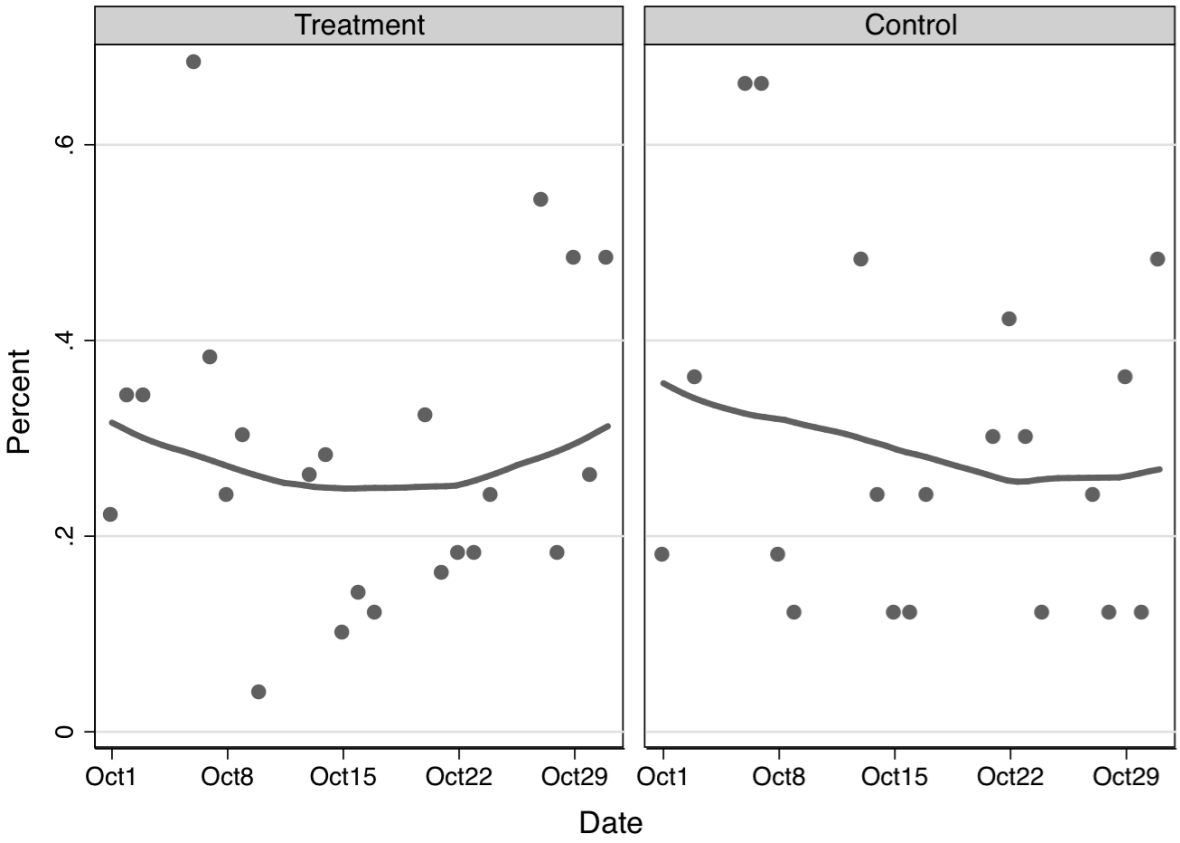
Variable	Definition
Demographics:	
Years of service	Total years of service.
Age	Age as of 10/31/2014
Annual 2013 salary	Annual salary earned in 2013.
Eligible for retirement	Employee qualifies for early or normal retirement when considering all the combinations of age at survey 1 and years of service by which an individual can qualify.
Years until eligible for retirement	For individuals not yet eligible, the minimum number of years before an employee can qualify for early or normal retirement when considering all the combinations of age at survey 1 and years of service by which an individual can qualify. Equals zero for those already eligible to retire.
Saving behavior:	
Increased contributions short-term	Aggregate increase in contribution between Nudge and 12/31/2014
Decreased contributions short-term	Aggregate decrease in contribution between Nudge and 12/31/2014
Made any changes to contributions short-term	Made any action to change contribution between Nudge and 12/31/2014
Increased contribution medium-term	Aggregate increase in contribution between Nudge and 08/15/2015
Made net changes to contribution medium-term	Aggregate increase or decrease in contribution between nudge and 8/15/2015
Balance change conditional on net change medium-term	Change in balance from 10/31/2014 to 8/15/2015 conditional on making net changes to contribution medium-term.
Contribution change conditional on net change medium-term	Amount of contribution change from 10/31/2014 to 8/15/2015 conditional on making net changes to contribution medium-term.

Appendix B: Extra Figures and Tables

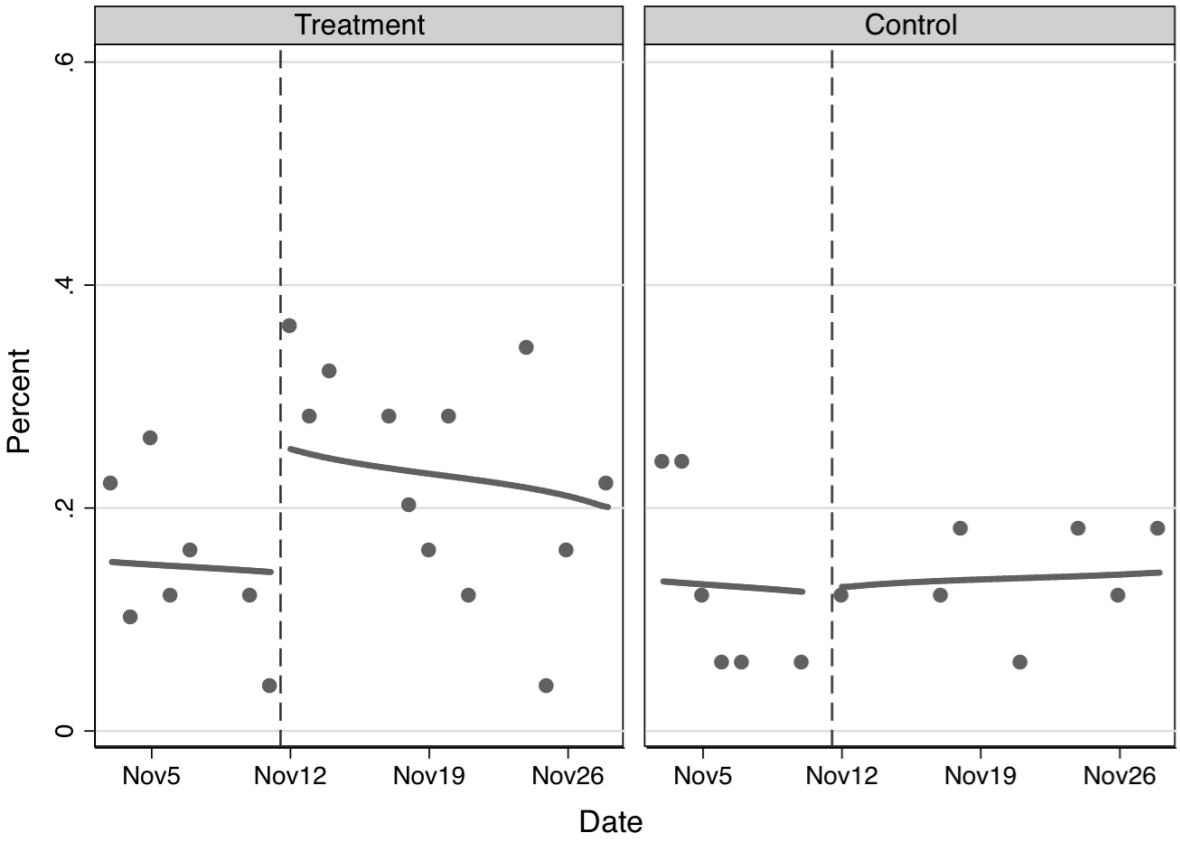
Appendix Figure B1:



Appendix Figure B2: Contribution Changes, Daily, Pre-and Post-Nudge, October



Appendix Figure B3: Contribution Changes, Daily, Pre-and Post-Nudge, November



Appendix Table B1: Heterogeneity in Treatment Effects, Alternative Outcomes

Panel A: Short-Term Any Change in Contributions

	Treatment Type	Gender	Salary	Age at Hire	Years of Service	Eligibility	Initial Balance	Initial Balance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All treatments	0.014**	0.005+	0.012	0.021**	0.009+	0.016**	0.003	0.013**
	(0.004)	(0.003)	(0.007)	(0.005)	(0.005)	(0.004)	(0.006)	(0.004)
x Longevity treatment	-0.008*							
	(0.003)							
x Tax advantage treatment	-0.002							
	(0.008)							
X Male		0.016+						
		(0.010)						
X Salary above median			-0.001					
			(0.014)					
X Age at hire above median				-0.019+				
				(0.010)				
X 20+ years of service					0.007			
					(0.009)			
X 5+ years until eligible						-0.021		
						(0.013)		
X Initial balance above median							0.020*	
							(0.011)	
X Initial balance > 90th pctile								-0.012
								(0.010)

Panel B: Medium-Term Net Change in Contributions

	Treatment Type (1)	Gender (2)	Salary (3)	Age at Hire (4)	Years of Service (5)	Eligibility (6)	Initial Balance (7)	Initial Balance (8)
All treatments	0.031*	0.028*	0.045*	0.037*	0.055**	0.036*	0.028*	0.040**
	(0.013)	(0.012)	(0.018)	(0.018)	(0.018)	(0.016)	(0.012)	(0.011)
x Longevity treatment	-0.006							
	(0.015)							
x Tax advantage treatment	0.021+							
	(0.011)							
X Male		0.017						
		(0.014)						
X Salary above median			-0.019					
			(0.024)					
X Age at hire above median				-0.002				
				(0.023)				
X 20+ years of service					-0.050+			
					(0.027)			
X 5+ years until eligible						0.000		
						(0.036)		
X Initial balance above median							0.016	
							(0.019)	
X Initial balance > 90th pctile								-0.042
								(0.038)

Appendix C: Survey Data

As part of the larger project described in Appendix A, we fielded a survey to a subset of all state and local government employees in North Carolina. Because our data include individual identification numbers, we are able to observe survey responses for some of our nudge participants. Appendix Table C1 confirms that receipt of the nudge did not alter the probability of retiring or the probability of responding to the survey. This is shown separately for the participant and non-participant group, although results are similarly insignificant when the two samples are pooled. Full information on the survey instrument and further information about the full project is available at: http://go.ncsu.edu/publicsectorretirement. The key dependent variables used in Table 7 are defined as follows.

Made a Retirement Plan

Have you already tried to figure out how much money you will need to have saved by the time you retire so that you can live comfortably in retirement?

- ○ **Yes, I have a retirement plan**
- ○ Yes, I have thought about this, but I do not yet have a plan
- ○ No, I have not yet thought about this

Those answering "agree" to the following:

Please indicate whether you agree or disagree with each of the following statements.

	Disagree	**Neither Agree nor Disagree**	**Agree**	**Not Applicable/ Don't know**
I expect to have enough money to live comfortably throughout my retirement.				
I am saving the right amount for my retirement.				

Appendix Table C1: Confirmation of Nudge and Retirement and Survey Responses

	Untreated	Treated	p-value of difference
Participant group (N=6192)	1561	4631	
Percent retired	14.0%	15.2%	0.26
Among active workers, sent a survey	302	891	
Number of survey responses	94	290	
Response rate to survey	31.1%	32.5%	0.64
Non-participant group (N=7608)	1524	6084	
Percent retired	11.9%	12.4%	0.58
Among active workers, sent a survey	290	1165	
Number of survey responses	81	306	
Response rate to survey	27.9%	26.3%	0.57