Mechanisms behind Retirement Saving Behavior: Evidence from Administrative and Survey Data*

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September 15, 2017

Abstract

Defaults have been shown to have a powerful effect on retirement saving behavior yet there is little research that aims to identify the mechanism. Using administrative data on employer-sponsored retirement accounts linked to survey data, we estimate the relationship between present bias, financial literacy, and exponential-growth bias with retirement saving choices. We find an important role for present bias in explaining why people fail to make active saving choices, maximize employer contributions and take advantage of tax-preferred saving opportunities. Our results also suggest a role for limited financial literacy and exponential-growth bias in explaining opt-in saving behavior and highlight the fact that mechanisms may differ depending on choice architecture. The results remain robust after controlling for measurement error using an instrumental variables technique. Our findings suggest that mitigating present bias can have large implications for retirement saving outcomes.

Keywords: present bias, exponential-growth bias, household finance; retirement saving decisions; choice architecture; defaults; financial literacy; procrastination.

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*Acknowledgments: This research was supported by the U.S. Social Security Administration through grant #RRC08098400-09 to the National Bureau of Economic Research as part of the SSA Retirement Research Consortium and by the TIAA Institute through grant #124652. The findings and conclusions expressed are solely those of the authors and do not represent the views of SSA, any agency of the Federal Government, the NBER, TIAA/TIAA Institute or any other institution with which the authors are affiliated. We are grateful to Paula Gablenz for exceptional research assistance.

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1 Introduction

Research on employer-provided retirement plans show that defaults, or the action that takes place if an individual makes no active choice, matter for retirement saving behavior (Madrian and Shea, 2001; Choi et al., 2004; Beshears et al., 2009). In addition, employees tend to remain at the default contribution rate, making the default rate a strong influence on saving behavior (Madrian and Shea, 2001; Choi et al., 2004; Besheears et al., 2009; Chetty et al., 2014).

Despite robust evidence on the effect of default provisions on retirement saving behaviors, little is known about the mechanisms driving these effects. The classical model predicts that defaults should have no effect on saving behavior. Even when transaction costs are required to make a change, the benefits of having an optimal contribution rate will almost always dwarf the relatively minor inconveniences of filling out paper work. Procrastination induced by present-biased preferences is a leading theoretical candidate (O'Donoghue and Rabin, 1999a,b; Besheears et al., 2009; Carroll et al., 2009; Bernheim et al., 2015). The transaction costs are immediate but the benefits of changing one's contribution are in the distant future. A naïve procrastinator may expect to make the change in the near future but delay indefinitely. Additionally, many Americans have low levels of financial literacy (Lusardi and Mitchell, 2014) and employees with lower understanding may avoid making a decision until they feel that they have sufficient understanding. Furthermore, ignorance or misperception of compound growth, known as exponential-growth bias (EGB), may lead employees to underestimate the cost of delaying action when their preferences do not align with the terms of the default (Stango and Zinman, 2009; Levy and Tasoff, 2016; Goda et al., 2015).

Though present bias (PB), financial literacy, and EGB are all plausible mechanisms for the powerful effect of defaults, alternative mechanisms could also explain the default effect. Employees may view the default has an endorsement from their employer or the default may serve as a salient anchor (Tversky and Kahneman, 1975; Ariely et al., 2003). Also, recent research shows that limited attention can lead to sticky behavior (Sims, 2003; Gabaix, 2014) and may also lead to unawareness that a choice is available.

Understanding the mechanisms behind defaults is important as it has direct implications for welfare and policy. If the stickiness of defaults is due to a perceptual bias, it indicates that in the absence of the bias, people would make different saving choices and therefore policies or interventions that mitigate that bias can be welfare-improving. If, by contrast, saving choices are orthogonal to these biases, it indicates a limited role for addressing these biases in changing saving outcomes. In addition, identifying the particular bias can inform the types of policies or interventions that may improve welfare.

In this paper we examine the relationship between present-biased preferences, financial illiteracy, and EGB with saving choices in an employer-provided retirement plan. Our approach combines administrative records on employee contribution behavior with direct, survey-based elicitations of PB, EGB, and financial literacy. We control for a rich set of covariates relevant to contribution decisions, including salary, demographics and education. We evaluate how these measures predict retirement saving behavior, in particular the failure to make an active choice, saving at default contribution rates, making any contribution, contributing to maximize the employer match, and contributing the annual maximum allowed by law in order to take full advantage of this tax-preferred saving opportunity. The data come from employees at the U.S. Office of Personnel Management (OPM), an agency that provides human resources, leadership, and support to most federal agencies.

We find an important role for present bias in the likelihood an individual passively enrolls at the default contribution rate when the default rate is sufficiently high, maximizes employer contributions, and takes full advantage of this tax-preferred saving opportunity. The magnitudes of our estimates are economically meaningful. A one standard deviation increase in our measure of PB corresponds to one-third lower likelihood of making an active choice and one-quarter lower likelihood of contributing the annual maximum. Financial literacy has a significant effect on contributing at the maximum level, with a one standard deviation increase in our measure of financial literacy corresponding to an 18 percent increase in the likelihood of being at the annual cap. Our survey was designed to address measurement error by including multiple measures of PB, the long-run discount factor, and EGB. The findings show that the results are robust to using two-stage least squares to control for measurement error, using methods from Gillen et al. (2017).

We also find that the mechanisms that explain why people remain at defaults may differ depending on what the underlying default is. Specifically, our results indicate that present bias explains whether people remain at a default contribution rate of 3 percent but that exponential-growth bias and financial literacy play a stronger role in explaining whether people do not contribute in the absence of automatic enrollment (in other words, when the default contribution rate is zero).

Past research relates measures of financial literacy and PB preferences to retirement wealth accumulation. Much of this prior work considers these explanatory factors one at a time, rather than jointly. It finds that financial literacy affects financial outcomes, including retirement planning (Lusardi and Mitchell, 2007; Hung et al., 2009), which in turn affects retirement savings (Lusardi and Mitchell, 2011; Ameriks et al., 2003). Heutel et al. (2014) find no relationship between PB preferences and whether people have any retirement savings. More recently, Goda et al. (2015) evaluate the relationship between retirement savings, PB preferences, financial literacy, and EGB, finding that each has a distinct and statistically significant relationship with retirement wealth. Stango et al. (2017) also find that PB preferences and EGB are among the set of factors that are highly predictive of overall financial condition, which includes retirement wealth. However, none of these papers examine the relationship between these individual characteristics under different default regimes.

This paper is most closely related to two recent studies that aim to explain saving choices with measures or proxies of present-biased preferences. Brown and Previtero (2014) create a measure of procrastination using administrative data by classifying anyone who enrolled in the company health plan on the last possible day as a procrastinator. They find that this measure of procrastination is a significant predictor of participation, contribution, and asset allocation decisions of employees. Another related study by Blumenstock et al. (2017) reports on a randomized-controlled trial in Afghanistan measuring the causal effects of employer-provided defaults and matches on short-term savings. Based on data from a follow-up survey that elicits time preferences, present-biased individuals were more likely to remain at the default. However, the institutional context and motivations for saving studied, namely short-term saving to an interest-free account in Afghanistan, differ greatly from the U.S. context.

Our paper makes several contributions to the existing literature. First, we combine direct elicitations of PB using conventional economic elicitation procedures with administrative data on saving in a U.S. context. This approach builds on Brown and Previtero (2014) by addressing concerns that using a revealed preference measure of procrastination, such as delays in health plan enrollment, could be driven by other contextual or psychological dispositions. For instance, it is possible that those who find the health plan enrollment confusing also find the retirement saving enrollment confusing. In addition, our survey allows us to control for other covariates not present in administrative data that may also affect saving decisions.

Second, our setting allows us to exploit saving outcomes in two different default regimes. In particular, a subset of our employees were hired prior to automatic enrollment and the remainder were hired following automatic enrollment. This change allows us to examine the relationship between PB, EGB and financial literacy and saving choices under different default provisions while holding other factors relatively constant. We find this dimension to be important, as our findings show that PB appears to influence whether someone passively accepts the default when the default contribution rate is 3 percent, while EGB and financial illiteracy seem to have a role in passive enrollment when the default is to not participate.

Finally, our data provide a variety of saving outcomes that allow us to examine the role that PB, EGB, and financial literacy have in explaining not only whether employees make active saving choices, but also whether they respond to match incentives and take full advantage of tax-preferred saving vehicles. Our results indicate an important role for present bias in failing to maximize employer contributions and failing to take advantage of tax-advantaged saving opportunities and a limited role for financial literacy in decisions to contribute the annual maximum contribution amount.

The remainder of this paper is organized as follows. In Section 2, we describe the context and our sources of data, including administrative records and linked survey responses. Section 3 describes the estimation technique in our paper and Section 4 presents the results. Section 5 concludes the paper.

2 Setting and Data

2.1 Retirement Plan Setting

Benefits-covered federal employees participate in an optional defined contribution (DC) plan, the Thrift Savings Plan (TSP), in addition to a mandatory defined benfit (DB) plan. Employees receive a base TSP contribution of 1 percent from the agency and a match on employee contributions up to 5 percent of pay. The agency matches each dollar of an employee's first 3 percent of pay and \$0.50 on the dollar for next two percent. Employees can contribute up to the IRS maximum each year, which is $18,000 in 2017.[1] Employees can elect to invest their contributions in five different funds or a lifecycle option, which is a mix of the other funds based on the employee's age.

The federal government implemented automatic enrollment for all covered employees hired after August 1, 2010. Under auto-enrollment, employees are enrolled in TSP at a 3 percent contribution rate, while employees hired prior to August 2010 had to opt in to participate in TSP. Therefore, the default contribution rate is zero for those hired prior to August 1, 2010 and 3 percent for those hired later.

Our administrative data combine TSP contribution elections with HR records. These data were collected as of April 2017, and include 5,472 employees. We fielded an online survey between March 29, 2017 to April 14, 2017 to these employees, and 1,585 (29%) provided complete response on the variables of interest. Our survey included one initial invitation and two reminders sent via email. We use this survey to elicit PB preferences, EGB and measures of financial literacy. These 1,585 employees form our analysis sample in this study.

2.2 Outcome variables

We construct each employee's annual TSP contribution amount using data on contribution elections while taking into account the maximum allowable annual contribution of $18,000.[2] We construct additional measures of saving choices including binary indicators of whether the employee passively enrolled, whether the employee's saving choice is consistent with the default in place during their hire date, whether the employee contributes an amount that maximizes their match from the Federal government, whether the employee contributes the annual maximum, and whether the employee contributes to TSP at all. The binary indicator describing whether the employee made a passive choice is only present for employees hired after auto-enrollment (AE) was instituted. This variable differs from whether the employee's saving choice is consistent with the default due to some employees actively electing the default contribution rate.

[1] Employees hired before 1984 are covered by a more comprehensive DB plan and receive no base and no match on employee contributions to TSP, although they are allowed to contribute up to the IRS maximum allowable each year. Fewer than 10 percent of the current full-time, non-seasonal employees are in the more comprehensive plan.

[2] Employees can elect DC contributions as a percent of pay, or as a dollar amount per pay period.

Table 1: Summary Statistics - Outcome Variables

	Hired Before AE	Hired After AE
TSP Amount ($/year)	8459.773	5223.404
	(6348.860)	(5076.433)
Passive		0.119
		(0.324)
At Default	0.092	0.147
	(0.289)	(0.354)
At Maximum Match	0.191	0.311
	(0.393)	(0.463)
At 0%	0.092	0.048
	(0.289)	(0.213)
At Cap	0.133	0.060
	(0.339)	(0.237)
Observations	829	756

Notes: TSP Amount reflects annual Roth and Traditional TSP contributions subject to annual maximum, including catch-up contributions if eligible. See text for more details.

Table 1 presents summary statistics for our main outcome variables separately for employees who were hired before and after the introduction of automatic enrollment. Because auto-enrollment is determined by hire date, and our data come from a single cross-section, auto-enrollment is confounded with length of service and, to some extent, with age. Employees hired before automatic enrollment (AE) have annual TSP contributions of $8,460 on average, while the younger cohort hired after AE average $5,223.

Approximately 9 percent of pre-AE employees are at their default contribution rate of 0 percent, whereas only 4.8 percent of post-AE employees do not participate. Instead, 14.7 percent of post-AE employees are at the post-AE default contribution rate of 3 percent. Our data include an indicator of whether the employee made an election or was passively enrolled in the plan. This variable indicates that the vast majority of those at the default contribution rate are there through passive enrollment: 11.9 percent of the sample, or 81 percent of post-AE employees, did not actively choose their contribution rate.

The two groups of employees also differ on their contributions at higher levels. Given that the agency matches contributions up to 5 percent of pay, we expect to find bunching at that level. Approximately 19 percent of pre-AE employees contribute 5 percent of their salary, while 31.1 percent of post-AE employees contribute 5 percent. Finally, we observe that whereas 13.3 percent of pre-AE employees are contributing the annual maximum of $18,000 per year, only 6 percent of post-AE employees are at this cap.

Figures 1–6 show our main outcomes by age and automatic enrollment regime at hire date. Figure 1 shows that TSP annual contributions are increasing in age, possibly due to increases in salaries, but surprisingly that the pre-AE cohort consistently contributes more than the post-AE cohort at any given age. Figures 2 and 3 show the stickiness of defaults. The share of employees who are entirely passive is approximately 30 percent of 25-year-olds but only 15 percent of those over 30, among post-AE employees. Figure 3 shows that this pattern is similar if one also includes those post-AE employees actively choosing the 3 percent default rate. Perhaps surprisingly, the share of pre-AE employees choosing the 0 percent pre-AE default rate is higher for older employees. Figures 4 and 6 show that for both groups, the share at the 5 percent maximum match decreases by roughly 0.5 percent per year of age, some of which may be explained by an increase in those at the $18,000 cap.

Figure 1: TSP Amount ($/year) by Age

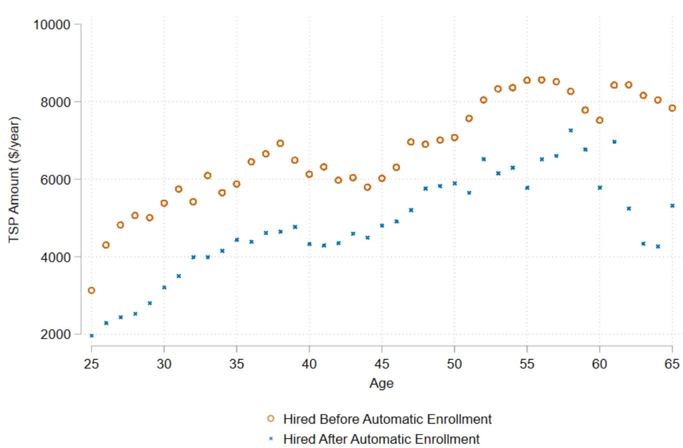


Figure 2: Share Passive by Age

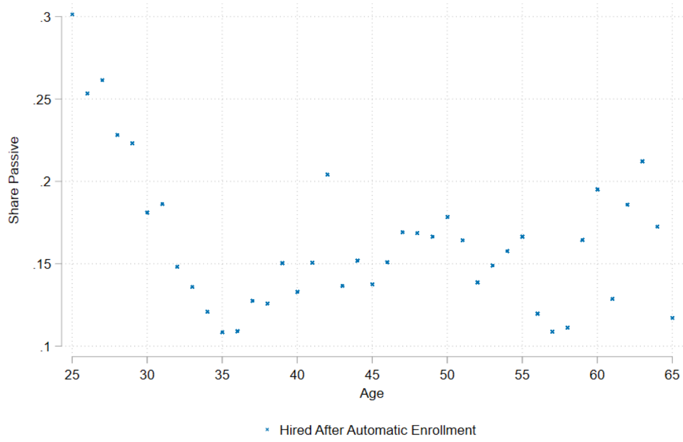


Figure 3: Share at Default Contribution Rate by Age

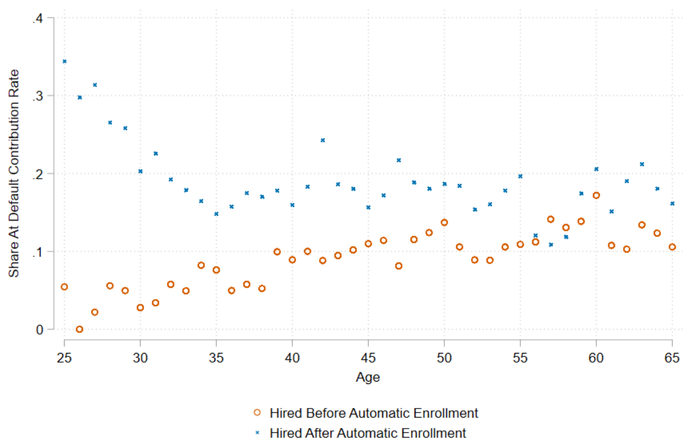


Figure 4: Share at Maximum Match Contribution by Age

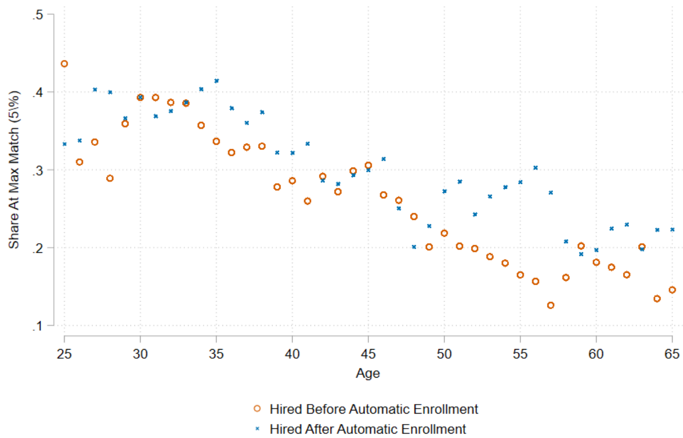


Figure 5: Share at 0% by Age

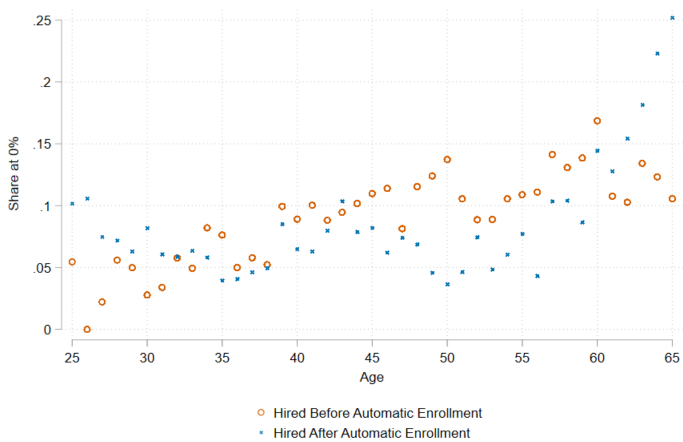
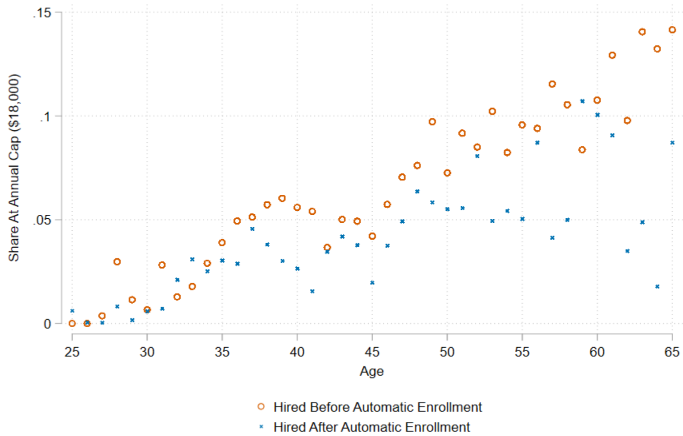


Figure 6: Share at Annual Cap by Age



2.3 Present bias

We adapt the "time-staircase" procedure from Falk, Becker, Dohmen, Huffman and Sunde (2014) to construct a simple measure of PB (Beta) as well as of the long-run discount factor (Delta). The staircases have the form:

Present-Future Staircase: Would you rather receive \$100 today or \$[X] in 12months?

Future-Future Staircase: Would you rather receive \$120 in 12 months or \$[Y] in 24 months?

Subjects begin with a common value of [X] or [Y]. If a subject indicates they prefer the money sooner (later), then the second dollar amount increases (decreases) on the next question.[3] For each staircase, subjects answer five questions, gradually narrowing the interval that contains the indifference point. Since the questions are binary and have parallel structure, they are easily understood and can be answered quickly.Â Participants were asked these questions for a 12-month (as shown above) and 6-month time interval, for a total of four sets.[4] We randomize the order of the staircases and utilize different base values for the different sets of questions (i.e., the Present-Future Staircase always begins with \$100 today and the Future-Future Staircase with \$120 in 12 months) to minimize the influence of mechanical responses. While this staircase method did not involve real stakes, Falk et al. (2014) show that behavior between a no-stakes and real-stakes version is

[3]In our survey instrument, the future value X was always greater than 100 and Y was always greater than 120.
[4]We collect multiple measures to address measurement error (see Section 3).

highly correlated.[5] From these staircases we construct measures of Beta and Delta from the implied indifference point.[6]

2.4 Financial literacy

We collect measures of financial literacy in the survey. First, we measure basic financial literacy using the 5-item battery of financial literacy questions developed by Lusardi and Mitchell (2011) and widely used since then (Lusardi and Mitchell, 2014).Â These questions measure understanding of inflation, diversification, compound interest, mortgage payments, and bond prices using multiple choice questions. OPM employees performed well on these questions relative to the U.S. population; percent correct ranged between 39 and 95 percent for OPM employees, and 21 to 70 percent for a representative sample of the U.S. population (Lusardi and Mitchell (2011)). Similarly, the share of employees who answered all five questions correctly was 30 percent, relative to 10 percent for the U.S. population, suggesting that OPM employees are more financially literate than average. In our subsequent analysis, we use a z-score of financial literacy standardized within the sample.

2.5 Exponential-growth bias

We measure EGB separately given that previous work has found that this bias is particularly important for retirement saving due to its long investment horizon (Stango and Zinman, 2009; Goda et al., 2015). To assess EGB, we include three hypothetical investment questions asking participants to provide a value for an asset given a specified return and time horizon. An example question is, "An asset has an initial value of \$100 and grows at an interest rate of 10% each period. What is the value of the asset after 20 periods?" For each question k and each individual i, we construct a measure of $\alpha_{i,k}$ that minimizes the distance between the response and the correct answer.

Our measure of Alpha represents the degree of EGB, with Alpha $= 1$ representing no EGB and Alpha < 1 representing negative EGB. We construct measures of Alpha for each participant using each asset question. We compute the distance the response is from the correct answer and

[5] The authors find a correlation between the staircase measures and incentivized experimental measures of 0.524.Â This correlation is close to the test-retest correlation of 0.664 for the incentivized experiment.

[6] We cannot identify the indifference point for those who select the upper bound of the time staircase. In this case, we use the upper bound value plus the difference between that value and the second-to-last value to determine the indifference point. We include a dummy variable for those with these imputed values in the analysis.Â

normalize it by the correct answer. Performance on these questions by OPM employees was similar to the U.S. population: between 29 and 33 percent of survey participants answered the questions within 10% of the correct value as compared to 23 to 31 percent in a representative U.S. sample (Goda et al., 2015).

2.6 Covariates

From HR records, we also have data on pay, basic demographics (gender, birth year, race/ethnicity), human capital (highest education, tenure), and position (team leader, manager or supervisor) and work location (DC, MD, PA, VA, other). Table 2 presents summary statistics of our measures of Alpha, Beta, Delta, the z-score for financial literacy, and our covariates that are included in all subsequent analyses. As shown in the table, the average value of Alpha is 0.48 which implies that on average, participants in our sample exhibit negative EGB. The average Beta of 1 implies that, on average, the sample is time consistent. However, individuals with Beta < 1 display PB and those > 1 are future biased, meaning that they over-value the future relative to today in a time inconsistent way. The mean of our sample for Alpha and Beta appear similar to the nationally-representative sample of Goda et al. (2015), while mean Delta of 0.87 indicates greater patience than in the national population, which had a 0.70 mean.

Table 2: Summary Statistics - Survey Measures and Controls

	mean	sd	min	max
Alpha	0.48	0.82	-1.00	3.00
Beta	1.01	0.09	0.65	1.40
Delta	0.87	0.09	0.65	1.00
Total Pay	86057.21	32249.94	26786.00	187000.00
Age	47.32	10.75	21.00	80.00
Tenure in Years	8.83	8.08	0.00	43.00
Trust in Fed. Gov. as Employer	3.23	1.05	0.00	5.00
Fin Lit (z-score)	0.01	0.99	-4.85	1.16
Eligible for Catch-Up Contributions	0.46	0.50	0.00	1.00
Highest Education				
High School	0.18	0.38	0.00	1.00
College	0.16	0.37	0.00	1.00
Bachelor	0.39	0.49	0.00	1.00
Post Bachelor	0.27	0.44	0.00	1.00
Race/Ethnicity:				
White	0.70	0.46	0.00	1.00
Hispanic	0.04	0.20	0.00	1.00
Black	0.21	0.41	0.00	1.00
Other Race	0.05	0.21	0.00	1.00
Work Location:				
DC	0.27	0.44	0.00	1.00
MD	0.09	0.29	0.00	1.00
PA	0.29	0.46	0.00	1.00
VA	0.05	0.21	0.00	1.00
Other Location	0.30	0.46	0.00	1.00
Job Position:				
Non-Supervisory	0.87	0.33	0.00	1.00
Team Leader	0.03	0.18	0.00	1.00
Supervisor or Manager	0.09	0.29	0.00	1.00
Observations	1583			

Notes: Trust in Fed. Gov. as Employer reflects level of agreement with the following statement: "Benefits by Fed. Gov. are designed to best fit the needs of its employees."

Fin Lit reflects number of correct answers among Big Five financial literacy questions.

3 Empirical Methods

We aim to understand the individual-level relationship between our survey measures of PB, EGB, and financial literacy and contribution decisions to an employer-sponsored retirement saving account. Unlike the administrative outcomes, there is good reason to believe that our survey measures are subject to considerable measurement error. Including multiple elicitations in our survey, however, provides us with two possible strategies for overcoming this.

The first strategy is simply to average the multiple measures and conduct OLS analysis using the mean value as a regressor. Under the assumption that our multiple measures of each characteristic are in fact noisy measures of a "true" characteristic and that the errors in the multiple measures are uncorrelated, then it follows trivially that the level of measurement error will be reduced but not eliminated by taking the means. As a result, using a mean value should yield less-biased results in OLS than using a single measure.

This OLS approach is not, however, the most efficient way of using our data. The second approach follows the "Obviously Related Instrumental Variables" (ORIV) approach of Gillen et al. (2017). A standard approach to dealing with a variable measured with noise is the use of an instrument uncorrelated with that noise. A second survey measure, provided the measurement error is uncorrelated, can provide such an instrument. However, experimenters often lack a theory for which survey measure should be the regressor and which the instrument. The ORIV solution is to use all measures simultaneously as regressors and as instruments for one another. That is, the true model is given by $Y = \alpha + \gamma X^*$, but the econometrician only has noisy measures $X^i = X^* + \nu_i$ for $i = 1, 2$ with ν_1 and ν_2 uncorrelated. One estimates the model:

$$\begin{pmatrix} Y \\ Y \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} + \gamma \begin{pmatrix} X^1 \\ X^2 \end{pmatrix}, \text{ instrumenting } \begin{pmatrix} X^1 \\ X^2 \end{pmatrix} \text{ with } W = \begin{pmatrix} X^2 & 0 \\ 0 & X^1 \end{pmatrix}$$

Gillen et al. (2017) prove that ORIV produces consistent estimates of γ (Proposition 1), and that the estimated standard errors, when clustered by subject, are consistent estimates of the asymptotic standard errors (Proposition 2).

While we can adapt this two-measure approach to our multiple-measure, multiple-outcome setting straightforwardly, the method places stronger demands on the relationships between the multiple measures. We therefore first determine for which parameters the ORIV approach is appropriate to allow us to utilize our data in a more efficient manner than the OLS approach.

In Table 3, we regress TSP contribution levels on our survey measures and other controls, considering all possible permutations of OLS and ORIV for Alpha, Beta, and Delta. The outcome in all eight columns is annual TSP contributions in dollars, as of April 2017. Column (1) is the most straightforward to interpret, being an OLS regression using the mean values of Alpha, Beta, and Delta as well as the standard controls. Both Beta and Delta are strongly related to TSP contributions, with estimated coefficients of $4,175 and $5,087 and significant at the 5 and 1 percent levels, respectively. This implies a one standard deviation increase in Beta is associated with $376 higher annual contributions, and a one standard deviation increase in Delta is associated with $458 higher annual contributions. These results are comparable to the $419 increase associated with a one standard deviation increase in our measure of general financial literacy, which is significant at the 1 percent level. The coefficient on Alpha is somewhat smaller at $248 and is not statistically significant.

The remaining columns of Table 3 attempt to use the ORIV strategy, first for one measure at a time, then two, then all three in Column (8). Which measures are instrumented are indicated in the rows immediately below the coefficient estimates. When only Alpha is instrumented in Column (2), the coefficient increases from $248 to $384, but remains just shy of statistical significance at conventional levels. Delta is instrumented in Column (4), which doubles its estimated coefficient to $10,326, which remains highly statistically significant. Unusually, when Beta is instrumented in Column (3), the coefficient becomes large and changes sign, becoming marginally significant at -$13,519. This occurs because our two Beta measures are not strong predictors of one another. Whereas the multiple Alpha measures are all correlated with each other with correlations above 0.4, and the two Delta measures correlated at 0.45, our two Beta measures are correlated only at 0.09 (a full correlation matrix is available in Appendix A). Attempting ORIV for Beta thus results in a weak instruments problem, suggesting that the technique is not appropriate for that measure.

Given that ORIV is not appropriate for Beta, the full ORIV approach shown in Column (8) is also not appropriate. Instead, the next best approach, and our preferred specification, is to use ORIV for Alpha and Delta, and simply use the arithmetic mean of Beta. This is shown in Column (6) of Table 3. The results are reassuringly similar to the preceding columns. The coefficient on Alpha remains economically meaningful at \$375, but marginally statistically insignificant. The coefficients on Beta and Delta are both large, at \$6,299 and \$9,227, respectively, and both significant at the 1 percent level. It is also worth noting that the coefficient on the general financial literacy score remains large and highly significant at \$424.[7]

In the following section, we use both the straightforward OLS specification from Column (1) as well as our preferred combination of OLS and ORIV from Column (6) to examine how our measures of Alpha, Beta and Delta are related to our other outcomes of interest to better understand the role of PB, EGB and financial literacy in retirement saving choices.

[7] We provide first-stage results for the specifications in Column (6) and Column (8) in Appendix A.

Table 3: Fitting TSP Contributions with OLS and IV specifications of Alpha, Beta and Delta

	(1) TSP Amt.	(2) TSP Amt.	(3) TSP Amt.	(4) TSP Amt.	(5) TSP Amt.	(6) TSP Amt.	(7) TSP Amt.	(8) TSP Amt.
Alpha	248.45	383.68	228.80	240.98	344.64	375.20	14.79	354.82
	(162.16)	(236.98)	(165.93)	(160.33)	(244.11)	(236.12)	(1115.45)	(242.58)
Beta	4175.54**	3994.42**	-13519.10*	6783.57***	-12966.66*	6298.77***	-102057.87	-10510.31**
	(1622.37)	(1657.56)	(7063.99)	(2143.84)	(7186.52)	(2175.64)	(491823.05)	(4372.68)
Delta	5087.70***	4598.34***	-2849.57	10325.92***	-2937.52	9227.25***	2837.89	-3029.96
	(1551.10)	(1570.60)	(3485.35)	(3274.63)	(3528.74)	(3278.95)	(18010.57)	(3424.51)
Fin Lit (z-score)	419.18***	432.87***	479.05***	410.95***	522.54***	423.93***	785.40	508.49***
	(150.06)	(154.58)	(154.80)	(150.29)	(161.53)	(156.24)	(1711.81)	(157.45)
Total Pay	0.10***	0.10***	0.10***	0.10***	0.10***	0.10***	0.15	0.10***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.22)	(0.02)
Total Pay × Total Pay	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age	49.47	67.22	9.54	60.68	27.71	77.36	-130.87	31.87
	(91.23)	(93.27)	(95.07)	(91.53)	(97.54)	(94.37)	(859.41)	(95.84)
Age × Age	-0.63	-0.85	-0.31	-0.72	-0.56	-0.94	0.80	-0.58
	(1.05)	(1.07)	(1.08)	(1.05)	(1.11)	(1.08)	(6.86)	(1.09)
College or Associate	233.23	188.66	416.70	100.48	357.63	77.27	155.01	362.20
	(428.37)	(437.37)	(436.45)	(434.17)	(446.73)	(445.86)	(1012.37)	(442.85)
Bachelor	1562.63***	1571.97***	1663.33***	1453.74***	1627.91***	1476.48***	1117.65	1648.67***
	(385.40)	(392.67)	(396.60)	(388.43)	(405.51)	(398.88)	(2107.11)	(403.26)
Post-Bachelor	1920.06***	1947.65***	2067.01***	1792.56***	2053.78***	1835.68***	1621.15	2070.44***
	(462.31)	(470.78)	(477.50)	(465.87)	(487.39)	(478.19)	(1507.76)	(485.28)
White	-1030.10	-956.72	-1092.15	-1058.60	-1003.71	-988.32	-1822.90	-984.43
	(740.97)	(736.15)	(762.96)	(735.46)	(762.47)	(737.46)	(3809.18)	(758.33)
Hispanic	-1419.34	-1296.35	-1238.62	-1483.00	-1110.04	-1359.63	-747.61	-1124.56
	(939.20)	(928.18)	(975.71)	(929.28)	(972.11)	(926.82)	(3735.41)	(962.24)
Black	-3000.53***	-2857.82***	-3226.10***	-2992.00***	-3005.63***	-2862.01***	-4630.60	-2976.26***
	(787.41)	(785.90)	(810.91)	(781.93)	(815.30)	(787.51)	(7665.32)	(809.09)
Tenure in Years	173.25***	174.08***	172.17***	169.39***	174.39***	170.67***	121.94	175.45***
	(60.54)	(61.61)	(62.64)	(59.95)	(64.00)	(61.57)	(259.77)	(63.51)
Tenure in Years × Tenure in Years	-4.38***	-4.47***	-3.97**	-4.36***	-4.06**	-4.47***	-1.07	-4.13**
	(1.68)	(1.73)	(1.74)	(1.66)	(1.80)	(1.73)	(15.59)	(1.78)
Eligible for Catch-Up Contributions	1664.66***	1708.48***	2002.76***	1589.68***	2040.11***	1643.90***	3413.84	1998.49***
	(497.48)	(504.57)	(540.12)	(496.06)	(551.29)	(507.05)	(8334.16)	(531.94)
Constant	-11295.31***	-11003.79***	13909.19	-18511.78***	13141.45	-17367.03***	100947.32	10656.99
	(3479.35)	(3534.49)	(10216.51)	(5290.48)	(10396.61)	(5323.60)	(524874.06)	(7210.39)
Alpha	OLS	IV	OLS	OLS	IV	IV	OLS	IV
Beta	OLS	OLS	IV	OLS	IV	OLS	IV	IV
Delta	OLS	OLS	OLS	IV	OLS	IV	IV	IV
F-Stat Alpha		521.47			261.52	267.17		179.79
F-Stat Beta			11.87		5.60		0.23	79.11
F-Stat Delta				101		50	262	253
Mean DV	7023.61	7031.85	7023.61	7023.61	7031.85	7031.85	7023.61	7031.85
R-squared	.371	.362	.285	.357	.283	.351	.	.305
Cluster	1396	1343	1396	1396	1343	1343	1396	1343
Observations	1396	4029	2792	2792	8058	8058	2792	16116

Notes: Standard errors in parentheses and clustered on ID. Dependent variables as indicated in column heading.

All specifications also include controls for Work Location, Job Position and Trust in Fed. Gov. as Employer.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4 Results

We analyze the relationship between Alpha, Beta, Delta and financial literacy and contribution choices by estimating our preferred specifications from Section 3 on our outcome measures described in Section 2. As described earlier, the adoption of automatic enrollment for new hires also allows us to understand the different effects these measures may have on saving choices based on the underlying choice architecture.

Our results are summarized in Tables 4 and 5. Table 4 uses the averaged values of Alpha, Beta, and Delta (analogous to Column (1) of Table 3), while Table 5 uses ORIV for Alpha and Delta, and the averaged Beta (analogous to Column (6) of Table 3). Our preferred specifications are in Table 5, but we present Table 4 for simplicity and transparency.

The first set of outcomes in Tables 4 and 5 consider the role of PB, EGB and financial literacy on the likelihood of passively sticking to defaults. The outcome in Column (1) represents whether employees were passively enrolled into the TSP. Because this outcome variable is only available for those hired after auto-enrollment, we limit the sample to this subsample, as indicated in a row below the regression results. The results show that failing to make an active choice is strongly correlated with Beta, but we find no evidence that it is correlated with Alpha, Delta, or financial literacy. The coefficient of -0.405 in Table 4 (-0.499 in Table 5) on Beta implies that a one standard deviation decrease in Beta, corresponding to more present bias, is associated with a 3.6 (4.5) percentage point higher probability of passive behavior. The magnitudes are economically significant, representing a 31-39 percent change relative to the mean.

We next examine the relationship between PB, EGB and financial literacy and whether the employee is contributing the default rate, which we can define for the full sample. For employees hired prior to auto-enrollment, this variable represents whether the employee is still at a zero percent contribution rate. For those hired after auto-enrollment, it represents whether the employee is at a 3 percent contribution rate and includes both those who were passively defaulted into the 3 percent contribution rate and those who actively selected it. Due to the possibility that these different default contribution rates have different potential for "stickiness" due to procrastination, we conduct our analysis separately on those hired before and after auto-enrollment. The results show no evidence that Beta is a predictor of remaining at the default when the default contribution rate is zero in Column (2), but strong evidence that lower levels of Beta (i.e. more procrastination tendencies) are associated with a higher likelihood of remaining at the default when the default contribution rate is 3 percent in Column (3). The coefficient on Beta of -0.558 in Column (3) of Table 4 implies that a one standard deviation decrease in Beta is associated with a 5.0 percentage point (34 percent) higher probability of being at the default. The results are slightly larger in magnitude in the corresponding column of Table 5.

While Beta does not predict remaining at the default contribution rate for employees hired prior to auto-enrollment, general financial literacy is statistically significant in Column (2) of Table 4 and both financial literacy and Alpha are marginally statistically significant in Column (2) of Table 5. The -0.028 coefficient on Alpha in Table 5 implies a one standard deviation increase in Alpha (less EGB) is associated with a 2.3 percentage point (20 percent) decrease in the probability of being at the zero-contribution default, and a one standard deviation increase in financial literacy is associated with a 1.7 percentage point (15 percent) decrease.

If employees move away from the default, we may expect to find bunching at the 5 percent rate which maximizes the agency match. Column (4) in each of Tables 4 and 5 examines whether our measures predict which employees are at the 5 percent contribution level. None of our survey measures seem to strongly predict which of the 25 percent of employees are bunching at the maximum match. Beta and Delta are each marginally significant in one specification but not the other, providing some weak evidence that more patient employees are less likely to bunch at this level. We also do not find strong evidence in Column (5) of Tables 4 and 5 that our measures predict whether employees are not contributing to TSP.

Finally, we examine the relationship between our measures and the $18,000 per year maximum annual contribution. Column (6) in both Tables 4 and 5 show strong evidence that less present-bias, more patience and higher levels of financial literacy are associated with a higher likelihood of contributing the annual maximum. The coefficients of 0.263 and 0.331 on Beta and Delta in Column (6) of Table 5 imply a one standard deviation increase in each is associated with a 2.4 percentage point (23 percent) and 3 percentage point (29 percent) increase in the probability of contributing the annual cap, respectively. Financial literacy is also a strong predictor: a one standard deviation increase predicts an increase of 1.8 percentage points (18 percent) in the likelihood of contributing the annual maximum.

Table 4: Relationship between Alpha, Beta and Delta and TSP Contribution - OLS Prediction

	(1) Passive	(2) At Default	(3) At Default	(4) At Maximum Match	(5) At 0%	(6) At Cap
Alpha	-0.003	-0.012	-0.021	0.014	-0.002	0.001
	(0.016)	(0.012)	(0.018)	(0.014)	(0.009)	(0.009)
Beta	-0.405**	0.200	-0.558***	-0.230	0.047	0.191**
	(0.174)	(0.145)	(0.193)	(0.153)	(0.095)	(0.084)
Delta	-0.100	0.054	-0.121	-0.241*	0.007	0.176**
	(0.162)	(0.130)	(0.177)	(0.143)	(0.089)	(0.089)
Fin Lit (z-score)	-0.007	-0.027**	-0.007	-0.001	-0.014*	0.017**
	(0.014)	(0.013)	(0.016)	(0.012)	(0.009)	(0.007)
Total Pay	-0.000***	-0.000	-0.000***	0.000*	-0.000	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Total Pay × Total Pay	0.000***	0.000	0.000***	-0.000**	0.000	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.004	-0.002	-0.010	-0.006	-0.008	0.003
	(0.010)	(0.009)	(0.011)	(0.010)	(0.006)	(0.005)
Age × Age	0.000	0.000	0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
College or Associate	-0.100**	0.023	-0.032	-0.039	0.011	0.013
	(0.051)	(0.047)	(0.055)	(0.040)	(0.031)	(0.020)
Bachelor	-0.034	-0.076*	0.013	-0.010	-0.070***	0.039**
	(0.047)	(0.039)	(0.049)	(0.037)	(0.024)	(0.019)
Post-Bachelor	-0.049	-0.104**	-0.012	0.039	-0.076***	0.056**
	(0.047)	(0.043)	(0.050)	(0.042)	(0.027)	(0.024)
White	0.060**	0.043	-0.021	0.032	0.020	-0.085
	(0.024)	(0.034)	(0.062)	(0.056)	(0.024)	(0.053)
Hispanic	0.112*	0.044	-0.004	-0.015	0.017	-0.089
	(0.059)	(0.054)	(0.082)	(0.074)	(0.036)	(0.064)
Black	0.121***	0.096**	0.017	-0.011	0.083***	-0.148***
	(0.034)	(0.042)	(0.068)	(0.059)	(0.031)	(0.054)
Tenure in Years	-0.041*	0.002	-0.039	-0.017***	0.004	0.007**
	(0.023)	(0.008)	(0.026)	(0.005)	(0.003)	(0.004)
Tenure in Years × Tenure in Years	0.005	-0.000	0.005	0.000***	-0.000	-0.000*
	(0.003)	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)
Eligible for Catch-Up Contributions	-0.026	-0.047	-0.023	0.002	-0.039	0.009
	(0.050)	(0.040)	(0.052)	(0.042)	(0.028)	(0.029)
Constant	1.033***	-0.097	1.466***	0.841**	0.198	-0.276
	(0.380)	(0.315)	(0.404)	(0.346)	(0.209)	(0.190)
Alpha	OLS	OLS	OLS	OLS	OLS	OLS
Beta	OLS	OLS	OLS	OLS	OLS	OLS
Delta	OLS	OLS	OLS	OLS	OLS	OLS
Sample	Hired After AE	Hired Before AE	Hired After AE	Full	Full	Full
Mean DV	.116	.088	.147	.249	.069	.102
R-squared	0.110	0.081	0.097	0.060	0.053	0.151
Cluster	661	735	661	1396	1396	1396
Observations	661	735	661	1396	1396	1396

Notes: Standard errors in parentheses and clustered on ID. Dependent variable in column heading.

All specifications also include controls for Work Location, Job Position and Trust in Fed. Gov. as Employer.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Relationship between Alpha, Beta and Delta and TSP Contribution Behavior - OLS/IV Prediction

	(1) Passive	(2) At Default	(3) At Default	(4) At Maximum Match	(5) At 0%	(6) At Cap
Alpha	-0.003	-0.028*	-0.030	0.021	-0.007	0.002
	(0.025)	(0.015)	(0.027)	(0.020)	(0.013)	(0.014)
Beta	-0.499**	-0.205	-0.628**	-0.362*	0.068	0.263**
	(0.227)	(0.154)	(0.247)	(0.201)	(0.124)	(0.116)
Delta	-0.212	-0.037	-0.242	-0.458	0.078	0.331*
	(0.334)	(0.218)	(0.361)	(0.293)	(0.179)	(0.185)
Fin Lit (z-score)	-0.012	-0.017*	-0.011	0.001	-0.013	0.018**
	(0.014)	(0.010)	(0.016)	(0.013)	(0.009)	(0.008)
Total Pay	-0.000***	-0.000***	-0.000***	0.000	-0.000	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Total Pay × Total Pay	0.000***	0.000***	0.000***	-0.000**	0.000	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.005	-0.008	-0.012	-0.005	-0.008	0.001
	(0.010)	(0.007)	(0.011)	(0.010)	(0.006)	(0.005)
Age × Age	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
College or Associate	-0.093*	0.010	-0.020	-0.032	0.007	0.009
	(0.052)	(0.035)	(0.056)	(0.041)	(0.032)	(0.021)
Bachelor	-0.038	-0.042	0.001	-0.000	-0.075***	0.035*
	(0.048)	(0.031)	(0.050)	(0.038)	(0.025)	(0.020)
Post-Bachelor	-0.059	-0.066**	-0.022	0.049	-0.085***	0.049**
	(0.048)	(0.033)	(0.051)	(0.043)	(0.027)	(0.025)
White	0.061**	0.013	-0.023	0.032	0.017	-0.095*
	(0.024)	(0.034)	(0.061)	(0.057)	(0.024)	(0.053)
Hispanic	0.115**	0.016	-0.003	-0.014	0.015	-0.097
	(0.059)	(0.048)	(0.081)	(0.075)	(0.036)	(0.064)
Black	0.108***	0.060	0.005	-0.008	0.078**	-0.148***
	(0.035)	(0.038)	(0.068)	(0.060)	(0.031)	(0.055)
Tenure in Years	-0.037	-0.003	-0.038	-0.017***	0.005	0.007**
	(0.023)	(0.003)	(0.026)	(0.005)	(0.003)	(0.004)
Tenure in Years × Tenure in Years	0.004	0.000	0.004	0.000***	-0.000	-0.000*
	(0.003)	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)
Eligible for Catch-Up Contributions	-0.041	-0.033	-0.042	0.014	-0.032	0.003
	(0.049)	(0.033)	(0.052)	(0.043)	(0.028)	(0.029)
Constant	1.189**	0.834**	1.601***	1.162**	0.134	-0.460
	(0.548)	(0.386)	(0.584)	(0.501)	(0.300)	(0.296)
Alpha	IV	IV	IV	IV	IV	IV
Beta	OLS	OLS	OLS	OLS	OLS	OLS
Delta	IV	IV	IV	IV	IV	IV
F-Stat Alpha	88.123	267.170	88.123	267.170	267.170	267.170
F-Stat Delta	21.560	50.449	21.560	50.449	50.449	50.449
Sample	Hired After AE	Hired Before AE	Hired After AE	Full	Full	Full
Mean DV	.114	.113	.143	.251	.068	.102
R-squared	.106	.066	.088	.053	.052	.14
Cluster	638	1343	638	1343	1343	1343
Observations	3828	8058	3828	8058	8058	8058

Notes: Standard errors in parentheses and clustered on ID. Dependent variable in column heading.

All specifications also include controls for Work Location, Job Position and Trust in Fed. Gov. as Employer.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5 Conclusion

This paper directly assesses potential mechanisms for explaining observed saving choices in the context of a large U.S. employer's retirement savings plan. In particular, we examine the role that present bias, exponential-growth bias, and financial literacy have in explaining whether employees make active saving choices, respond to match incentives and take full advantage of tax-preferred saving vehicles.

Our results indicate an important role for present bias in failing to make an active choice, failing to move away from the default contribution rate when it is sufficiently high, failing to maximize employer contributions, and failing to take advantage of tax-advantaged saving opportunities. Our findings also suggest a role for limited financial literacy and exponential-growth bias in explaining why individuals do not choose to opt in to tax-preferred saving vehicles when the default is to not participate, though this evidence is not as strong. Financial literacy has a significant effect on contributing the annual maximum contributions.

This study also highlights the importance of examining the mechanisms behind retirement saving choices and the likelihood of sticking with defaults differentially based on the underlying choice architecture. Specifically, we find that present bias explains whether people remain at a default contribution rate of 3 percent but that exponential-growth bias and financial literacy may play a role in explaining whether or not employees contribute in the absence of automatic enrollment.

Our findings suggest a significant role for understanding ways to mitigate present bias, exponential-growth bias and financial literacy in order to change saving outcomes and ultimately improve welfare. Identifying potential interventions that achieve this remains an important area for future research.

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Appendix A Additional Tables

Table A.1: First Stage for Column (6), Table 1

	(1)	(2)
	Alpha	Delta
IV Alpha 1	0.307***	0.000
	(0.013)	(0.001)
IV Alpha 2	0.307***	0.000
	(0.013)	(0.001)
IV Delta	0.032	0.333***
	(0.072)	(0.033)
IV Beta	-0.075	-0.333***
	(0.119)	(0.019)
Mean DV	.505	.871
R-squared	0.290	0.266
Cluster	1343	1370
Observations	16116	16224

Notes: Standard errors in parentheses and clustered on ID. Dependent variable in column heading. Controls include: Total Pay Squared, Age Squared, Tenure Squared, Fin Lit (z-score), Education, Race, Job Location, Trust in Fed. Gov as Employer, Catch-Up Eligibility.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2: First Stage for Column (8), Table 1

	(1)	(2)	(3)
	Alpha	Beta	Delta
IV Alpha 1	0.308***	-0.001	0.001
	(0.013)	(0.001)	(0.001)
IV Alpha 2	0.308***	-0.001	0.000
	(0.013)	(0.001)	(0.001)
IV Beta	-0.034	-0.097**	-0.150***
	(0.054)	(0.039)	(0.008)
IV Delta	0.045	-0.352***	0.392***
	(0.068)	(0.023)	(0.031)
Mean DV	.505	1.006	.871
R-squared	0.290	0.096	0.233
Cluster	1343	1370	1370
Observations	16116	16224	16224

Notes: Standard errors in parentheses and clustered on ID. Dependent variable in column heading. Controls include: Total Pay Squared, Age Squared, Tenure Squared, Fin Lit (z-score), Education, Race, Job Location, Trust in Fed. Gov as Employer, Catch-Up Eligibility.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.3: Correlation Matrix

	Mean Alpha	Alpha 1	Alpha 2	Alpha 3	Mean Beta	Beta 1	Beta 2	Mean Delta	Delta 1	Delta 2
Mean Alpha	1.000									
Alpha 1	0.826^{***}	1.000								
Alpha 2	0.822^{***}	0.540^{***}	1.000							
Alpha 3	0.773^{***}	0.416^{***}	0.444^{***}	1.000						
Mean Beta	-0.004	-0.005	-0.012	0.005	1.000					
Beta 1	-0.018	-0.012	-0.028	-0.008	0.865^{***}	1.000				
Beta 2	0.020	0.009	0.022	0.023	0.576^{***}	0.087^{***}	1.000			
Mean Delta	0.035	0.032	-0.001	0.051^{*}	-0.466^{***}	-0.438^{***}	-0.211^{***}	1.000		
Delta 1	0.017	0.016	-0.007	0.036	-0.495^{***}	-0.624^{***}	0.033	0.870^{***}	1.000	
Delta 2	0.045	0.040	0.005	0.052^{*}	-0.286^{***}	-0.091^{***}	-0.419^{***}	0.832^{***}	0.449^{***}	1.000
Observations	1583									

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.