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AUTO-ENROLLMENT, MATCHING, AND PARTICIPATION IN 401(K) PLANS

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Abstract

This study uses plan-level annual data from Form 5500s to analyze the effects of automatic enrollment and employer matching on 401(k) plan participation rates, and the effect of automatic enrollment on employer average match rates. The potential endogeneity of these 401(k) plan provisions is addressed by exploiting the panel structure of the data. The results indicate that while both auto-enrollment and average match rates have positive and significant effects on plan participation rates, the effect of auto-enrollment is substantially higher. Moreover, auto-enrollment is found to have positive and significant effects on average match rates.

JEL classification: D14, G23, J32
Keywords: 401(k) Plans, Participation Rate, Auto-enrollment, Matching, Fractional Response Models, Unbalanced Panel Data

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1 Introduction

How does the design of 401(k) pension plans affect employee participation rates? Is there a trade-off between 401(k) plan design features that may affect retirement savings outcomes? Finding a convincing answer to these questions is relevant both to plan sponsors and to policy makers. Plan sponsors could design their 401(k) plans better in order to attain certain objectives, such as developing stronger incentives for employee savings, offering more attractive benefit packages to recruit and retain higher-quality workers, and achieving a mix between employee elective deferrals and employer contributions that satisfies the IRC nondiscrimination requirements. Policy makers, concerned that many workers may be saving too little for retirement, may implement policies that promote participation in 401(k) plans effectively.

The relevance of these questions in the current debate has increased with the rapid growth of 401(k) plans, a phenomenon that has profoundly changed the US pension landscape. Not only have defined contribution (DC) plans supplanted the traditional defined benefit (DB) plans as the primary retirement savings vehicle; They have also raised concerns over their significantly lower take-up rates. This has led policy makers and academics alike to focus on two key features of 401(k) plan design – employer matching and automatic enrollment – that are intended to have an indirect and direct impact, respectively, on plan participation rates.

On the policy side, following concerns that the tax-deferred nature of 401(k) plans contributions may disproportionately attract highly compensated employees (HCEs), different policies have been implemented over time, providing incentives for employers to encourage participation of non highly compensated employees (NHCEs) either through matching contributions[1] or by reversing the participation default.[2] Nonetheless, survey data show that the dramatic shift in employer sponsorship from defined benefit (DB) to defined contribution (DC) – 401(k) – plans over the last two decades has not been accompanied by a rise in participation among eligible workers: 401(k) plans' take-up rates remained stable around 70%, well below the 90% typical of DB plans.[3]

[1]Mandatory nondiscrimination tests were introduced by The Tax Reform Act of 1984 and 1986. Moreover, the Small Business Job Protection Act of 1996 introduced safe harbors allowing employers to avoid nondiscrimination testing by providing a sufficiently generous match.

[2]The possibility of switching the default for 401(k) eligible employees from *opt-in* to *opt-out* – i.e., to automatic enrollment – was strongly encouraged with the passage of the Pension Protection Act of 2006 (PPA '06). This law provides an optional nondiscrimination safe harbor, as well as protection from fiduciary liability and from state payroll-withholding laws for plans with automatic enrollment (O'Hare and Amendola, 2007).

[3]Data from the National Compensation Survey indicate that in 2012 (2009), still only 41% (43%) of the 59% (61%) eligible private industry workers participated in a 401(k) pension plan – corresponding to a 70% take-up rate (US Bureau of Labor Statistics, 2010, 2012). Similar take-up rate figures are provided by Purcell (2009) for earlier years – 69, 74, and 71% for 1998, 2003, and 2006, respectively – using data from the Survey of Income and Program Participation.

Although the relationship between 401(k) plan provisions and participation rates has been extensively studied in the literature (see Madrian, 2013, for a review, and Table 1 for a summary description of these studies), the latter evidence calls for further contributions. For once, while a consensus has emerged that employer matching positively affects participation in 401(k) plans with standard enrollment, the magnitude of the findings varies considerably. Furthermore, there is little evidence on whether a more generous match is associated with higher participation rates in plans that have automatic enrollment. Finally, while the most convincing evidence comes from studies that exploit quasi-experimental variation at the firm level, the use of firm-specific data also represents a limit to the generalizability of these findings.

A related literature has recently addressed concerns that employers might respond to the higher costs associated with automatic enrollment by reducing their matching contributions. However, the available evidence on the relationship between automatic enrollment and matching is descriptive in nature, and provides conflicting accounts (Adams, Salisbury, and VanDerhei, 2013).

I address these questions by estimating participation and match rate equations on plan-level panel data. The data are taken from the Form 5500 that US sponsoring employers are required to file annually, and represent the population of medium and large 401(k) plans over the period 2009-2012. Focusing on this particular time windows offers several advantages. First, since 2009 employers sponsoring a 401(k) plan are required to report in the 5500 Form if the plan provides automatic enrollment. I exploit this information to define an auto-enrollment dummy variable that represents a regressor of interest in the empirical analysis. Moreover, I can use the intense dynamics that auto-enrollment and matching provisions experienced over this period – following PPA '06 enactment and the 2008 crisis, respectively – as a source of identifying variation. Finally, these data represent the most recent release of 5500 Form data.

My approach has three key components. First, I use panel data methods to control for unobservable time-invariant plan/sponsor-specific traits potentially correlated with the regressors of interest, while accounting for the fractional nature of plan participation rate as a dependent variable. Under the assumption of strict exogeneity – i.e., in the absence of "dynamic selection" – my panel estimates are robust to threats to internal validity that represent cause of concern in studies exploiting only natural cross-sectional variation. Second, using data on the population of 401(k) plans confers to my results the external validity lacking in earlier studies, mostly based on non-representative data. Using population data also attenuates issues of limited within-unit time-variation typically arising with fixed effect (FE) estimators. Finally, the empirical analysis is carried out by type of 401(k) plan. This allows a better characterization of plan design choices that may be specific to each plan type. The robustness of the results is further assessed using different model specifications and estimation samples.

I provide three main findings. First, consistent with earlier literature findings, I find that while both auto-enrollment and average match rates have positive and significant effects, auto-enrollment plays a prominent role in boosting participation rates. This holds even when the effect of the match is identified by exploiting an extreme variation – i.e., a suspension or reinstatement – of the match. Interestingly, panel estimates reveal upward biases of OLS estimates based on pooled cross-sectional samples. This is consistent with the view that auto-enrollment and matching provisions in 401(k) plans are mainly driven by the employers' desire to offer an attractive benefit package to recruit and retain higher-quality workers (Ippolito, 2002), rather than by non-discrimination testing purposes.[4] Moreover, I find that offering a match does not significantly increase participation in plans with automatic enrollment. Finally, I find that, while OLS estimates based on pooled cross-sectional samples point towards heterogenous effects of auto-enrollment, depending on plan type, FE estimates generally indicate positive and significant effects. This finding suggests that a complementarity – rather than a trade-off – may be at work between these key 401(k) plan design features, and is in stark contrast with the evidence provided so far in the literature (Soto and Butrica, 2009; Butrica and Karamcheva, 2015).

The literature on 401(k) plan design has delivered conflicting accounts of how 401(k) provisions affect participation. Studies that focus on the relationship between employer matching and plan participation provide a wide range of findings, as illustrated in Table 1. This is most likely due to the data and/or the source of match variation exploited. Studies that exploit the naturally occurring match rate variation in cross-sectional representative samples raise concerns over either the potential endogeneity of the employer match rate (see, among others, Bassett, Fleming, and Rodrigues, 1998) or the validity of the instruments used to address this endogeneity issue (Even and Macpherson, 2005; Dworak-Fisher, 2011). By contrast, studies that exploit arguably exogenous natural experimental variation in match rates are based on firm-specific data (Kusko, Poterba, and Wilcox, 1998; Choi, Laibson, Madrian, and Metrick, 2002, 2006), and therefore have limited external validity. Finally, studies that exploit the naturally occurring match rate variation in cross-sectional non-representative samples of 401(k) plans (Clark and Schieber, 1998; Clark, Goodfellow, Schieber, and Warwick, 2000; Huberman, Iyengar, and Jiang, 2005; Mitchell, Utkus, and Yang, 2007) are limited in both their internal and external validity.

In contrast, numerous studies have shown that, relative to the standard opt-in approach, automatic enrollment dramatically increases plan participation, both for newly hired (Madrian and Shea, 2001; Choi, Laibson, Madrian, and Metrick, 2002, 2004, 2006)

[4]In contrast, IV match estimates provided by Even and Macpherson (2005) and Dworak-Fisher (2011) suggest that a failure to account for the possible influence of employee saving preferences on employer matching may lead to an understatement of the impact of matching on employee participation. These findings are consistent with the alternative view that employer matching responds to non-discrimination testing compliance.

and for previously hired employees (Choi, Laibson, Madrian, and Metrick, 2004; Beshears, Choi, Laibson, and Madrian, 2008). By exploiting quasi-experimental variation at the firm-level, these studies adopt the most convincing identification strategies. However, the use of firm-specific data also represents a limit to the generalizability of their findings.

Finally, the growing popularity of automatic enrollment has raised questions about the role of employer matching contributions in effective 401(k) plan design, and on the existence of a possible trade-off between these two key provisions (Adams, Salisbury, and VanDerhei, 2013). The evidence available so far suggests that the success of automatic enrollment at increasing participation does not appear to rely much on having an employer match (Beshears, Choi, Laibson, and Madrian, 2010), and that there is a negative relationship between between the employer decision to adopt automatic enrollment and the generosity of the employer match (Soto and Butrica, 2009; Butrica and Karamcheva, 2015).[5] The inference that can be drawn from these studies is however limited, as they do not address potential endogeneity issues that could confound the estimates. Moreover, the use of firm-specific data, or of cross-sectional samples covering only sponsoring firms or specific plan types within the 401(k) category, limits the generalizability of these findings.

This study contributes to these literatures by shedding further light on the role of auto-enrollment and employer matching in raising participation rates, as well as on the relationship between these two key 401(k) provisions. The next section provides background on 401(k) plans. Section 3 describes the data. Section 4 illustrates the empirical analysis and discusses the results. Section 5 concludes.

2 Background

A 401(k) plan legally is not a separate DC type of plan, but qualifies for tax purposes – under IRC section 401(a) – as a Profit Sharing (including Thrift-Savings) or Stock Bonus (including Employee Stock Ownership (ESOP)) plan, which contains a "Cash Or Deferred Agreement (CODA)". Although these legally different types of 401(k) plans share many similarities, in practice the choice of the sponsoring employer to offer a particular plan type depends on the degree of flexibility offered by each plan type as a tool for reaching the employer's objectives, as well as on the costs involved in setting up and administering the plan. For example, profit sharing and stock bonus/ESOP plans are typically aimed at fostering employee commitment to company goals. While a traditional profit-sharing plan allows employees to share in a company's success allocating profit-sharing contributions, a stock bonus plan/ESOP contributes cash and/or stocks to an account held on behalf of the sponsor's employees, providing them with an ownership stake in the company.

[5]However, VanDerhei (2010) contradicts these results, providing descriptive evidence that employer match rates increased over time among employers that switched to automatic enrollment in a sample of large 401(k) plans.

Whatever legal setup is chosen for a plan containing a CODA, a common element of 401(k) plans is that employees are required to contribute a portion of their salary – known as *elective deferral* – to the plan in order to participate. Plan participants are always allowed *before-tax* elective deferrals, and, depending on the plan, may also be allowed *after-tax* and/or *Roth* deferrals.[6]

Although sponsoring employers are not required to contribute to their 401(k) plans, they usually do. Employer contributions may be *non-matching* (or *non-elective*), made at the sole discretion of the employer, or *matching*, made by the employer in response to an elective deferral.[7] Non-matching contributions are typical in profit-sharing plans and may be structured as a variable or fixed profit sharing contribution. If a contribution is made, it has to be allocated to eligible plan participants based on an *allocation formula*.[8] Matching contributions can be determined on a *formula basis* or be *discretionary*, i.e., determined by the employer each year. A formula-based match can be *single-tier* – with employee elective deferrals matched at a flat rate up to a *match threshold*, defined as the maximum percentage of the employee compensation to which the match applies – or *multi-tier* – with different match rates applied to different match thresholds. Under other match designs, the match rate can be related to the employee's length of service or to the level of employee's deferrals. Finally, some plans cap the match amount to a pre-specified $ amount (e.g., $2,000).[9]

Employers offer matching contributions for two main reasons. First, as a means to comply with non-discrimination tests, by encouraging NHCEs' participation.[10] Nondis-

[6]Before-tax deferrals are deductible from current-year income, but contributions – including matching and/or non-elective employer contributions –, interest, and capital gains accumulated in the individual account set up under the plan are taxed at ordinary income rates upon distribution. In contrast, after-tax and Roth deferrals are not deductible from current-year income. However, contributions – excluding matching and/or non-elective employer contributions –, interest, and capital gains accumulated into a Roth account held for at least 5 years are allowed tax-exemption if distributed under "qualified" circumstances (death, disability, or reaching age $59\frac{1}{2}$).

[7]Within these broad categories, there is a wider variety of types of employer contributions, based on whether the contributions are used for *non-discrimination testing* or for *safe harbor* purposes.

[8]Some formulas – such as age-weighted, integrated and new comparability – are designed to favor owners, older, long-term, highly compensated and key employees without being discriminatory.

[9]Vanguard (2010) reports that, in a sample of more than 2,000 401(k) plans administered in 2009, more than 200 distinct match formulas were offered. Single-tier match formulas were the most popular – offered by 75% of plans –, while 17% of plans offered multi-tier formulas. Similarly, data from the 2009 National Compensation Survey (US Bureau of Labor Statistics, 2010) indicate that 62% of participants in 401(k) thrift-savings plans sponsored by medium and large firms were offered a single-tier match.

[10]401(k) plans are required to pass two tests to ensure that they do not discriminate in favor of HCEs. The *average deferral percentage* (ADP) test compares HCEs and NHCEs average elective deferral percentages – including pre-tax and Roth, but excluding catch-up deferrals –, while the *average contribution percentage* (ACP) test – defined under IRC section 401(m) – compares HCEs' and NHCEs' average matching contributions plus after-tax deferrals. For most companies, the HCE average cannot be more than 2 % higher than the NHCE average. Failure of the ADP/ACP test indicates that there has been an excess elective deferral/matching contribution for the HCEs. In this scenario, the employer may bring the plan into compliance either by reducing the HCEs' elective deferrals – through corrective distributions and/or

crimination rules are binding for many firms, and may affect plan design. As an alternative explanation, employers may offer matching contributions to attract and retain higher quality workers. Ippolito (2002) suggests that firms match employee contributions to attract and retain workers with a desirable but unobservable attribute – a low discount rate. He provides empirical evidence that workers with lower discount rates are less likely to quit or call in sick, and generally receive higher performance ratings. Because matching provides a higher level of compensation to savers – i.e., those with low discount rates who choose to take advantage of the matching contribution –, a 401(k) plan with matching will help attract and retain them.

Besides employer matching, another key feature of current 401(k) pension plan design aimed at increasing employee participation is automatic enrollment. Although initially introduced in 1998, it was only after the enactment of the provisions included in the PPA '06 – from plan-years beginning on January 1, 2008 – that auto-enrollment was given a leg up. Employers sponsoring a 401(k) plan can currently offer their employees either a standard or an automatic enrollment protocol, which essentially defines opposite participation (and contributions/investments) defaults. Under the standard enrollment protocol, an active election on the part of the employees is required to *opt-in*, the default being non-participation. In contrast, under the automatic enrollment protocol, an active election choice on the part of employees is required in order to *opt-out*, the default being participation. Moreover, under automatic enrollment, the employee is offered a default contribution rate, as well as a default investment.

3 Data

The data used in this study are taken from the *Form 5500 Annual Return/Report of Employee Benefit Plan (Form 5500)* filings for pension plan sponsors.[11] Filers are classified as either single-employer, multiemployer, multiple-employer or direct filing entities (DFEs).[12] Sponsoring employers are identified by their unique federal EIN number, while

re-characterization – or increasing the ADP/ACP of the NHCEs – through *qualified non-elective contributions* (QNEC) or *qualified matching contributions* (QMC). Non-discrimination testing can be avoided in a particular plan-year if the sponsoring employer elects to comply with one of the available IRC safe harbors: with or without automatic enrollment, and with non-elective or matching contributions.

[11] While beginning January 1, 2010 all Form 5500 filings are required to be submitted electronically – through the *EFAST2* system – a substantial part of the 2009 filings were already submitted using this system, rather than using the traditional *EFAST* system. The original filings can be downloaded from https://www.efast.dol.gov/portal/app/disseminate?execution=e1s1.

[12] Single-employer plans are plans that are maintained by one employer or employee organization. Multiemployer plans are established pursuant to collectively bargained pension agreements negotiated between labor unions representing employees and two or more employers, and are generally jointly administered by trustees from both labor and management. Multiple-employer plans are plans maintained by more than one employer and are typically established without collective bargaining agreements. DFEs are trusts, accounts, and other investment or insurance arrangements that plans participate in and that are required to or allowed to file the Form 5500.

sponsored plans are identified by a unique PN number within each employer. This allows longitudinal matching of the plan filings, except in the rare event that a sponsor's EIN did change from year to year.

3.1 The Private Pension Plan Research Files

For the purpose of the empirical analysis, I use the Form 5500 *Private Pension Plan (PPP) Research Files* provided by the Employee Benefits Security Administration (EBSA) of the US Department of Labor (DOL).[13] Data for the *PPP Research Files* is taken only from the main Form 5500 and Schedule H (Financial Information) for large plans (100 or more participants), and from Form 5500 - SF and Schedule I (Financial Information) for small plans (less than 100 participants).[14]

The main advantage of using the *PPP Research Files* rather than the raw Form 5500 data is that incorrect EINs, participant counts, contribution amounts, and other data issues are explicitly addressed. Moreover, duplicate filings are flagged, and can therefore be eliminated.[15] Through 2009, the *PPP Research Files* were designed to contain all filings of pension plans with 100 or more participants and a 5% sample of smaller plans, selected on the basis of digit patterns in the sponsor's EIN. Starting in 2010, the *PPP Research Files* were designed to contain all pension plan filings, regardless of size.

My sample is limited to single-employer sponsored 401(k) plans with more than 100 participants observed during the period 2009-2012. This particular time window is chosen to exploit the most recently available data containing a new feature of the 5500 Form. Since 2009 – following PPA '06 enactment – employers sponsoring a 401(k) plan are required to report in the 5500 form if the plan is adopting automatic enrollment. This information is used to define a time-varying dummy variable taking the value one for auto-enrollment plans.

Another key feature of 401(k) plan design is represented by the employer match rate, as defined in the plan documents and communicated to eligible participants through a Summary Plan Description (SPD). A drawback of using Form 5500 data is that they do not contain information on the formula used by plan sponsors to determine their matching contributions. Plan sponsors are required to report only total employer contributions – differentiating between cash and non-cash contributions, but not between matching and non-matching contributions – and total employee salary deferrals – without separate indication of their before-tax, Roth, or after-tax nature. The *average match rate* is therefore

[13] Publicly available at http://www.dol.gov/ebsa/publications/form5500dataresearch.html.

[14] The raw Form 5500 data include further schedules with accompanying attachments, containing information that is not relevant to our empirical analysis. Beginning in 2009, small plans are allowed to fill a simplified Form 5500-SF rather than the main Form 5500 and its schedules.

[15] *PPP Research Files* exclude filings by direct filing entities (DFEs) and by one-participant plans.

defined – following Papke (1995) – as the ratio of employer to employee contributions.[16] This is used as dependent variable in the empirical models estimated to investigate the relationship between auto-enrollment and employer matching. Together with the auto-enrollment dummy, it also acts as a regressor of interest in the models that explain plan participation rates. Additional specifications of the latter models include either a dummy variable indicating whether an employer match is available, or a set of dummy variables defining average match rate intervals, or, finally, an interaction term between automatic enrollment and the average match rate.

Although with individual-level data it would be preferable to know the marginal match rate facing each participant at each point in time, with plan-level data an average match rate may be preferable (Papke, 1995). First, match formulas may be step functions of employee deferral levels, or may be based on firm profitability. For example, the 401(k) plan may base some part of the match rate on the performance of the company – as it is typical in profit sharing plans –, or offer a discretional matching contribution not explicitly defined in the SPD. Second, the average match rate – i.e., the ratio of employer contributions to employee deferrals – includes any flat per-participant employer contribution and any corrective contribution the employer had to make to pass the anti-discrimination tests. Third, among the minority of plans electing a safe harbor status, safe harbor matching plans are the typical choice.[17] Finally, a company might not match after-tax contributions, but among the types of contributions it does match, the match formula typically does not vary by the type of contribution. Considering also that before-tax and Roth deferrals are usually a better deal than after-tax contributions, the average match rate understatement that would follow from overstating the elective deferrals that can be matched by employer contributions should be negligible. Summarizing these arguments, while an average match rate based on the ratio of employer to employee contributions may be overstated – therefore exceeding the marginal participation/contribution incentive facing each eligible participant – it may still represent a good indicator of the overall plan generosity, capturing contributory elements that would be overlooked by marginal match rates defined in plan match formulas. Moreover, if the average match rate were systematically overstated (or understated), the FE estimator would make it possible to eliminate this bias. In any case, given the attenuation bias that a measurement error in average match rates would introduce in its estimated coefficients, my results could still be considered as a lower bound of the impact of match rates on plan participation.

Regarding plan participation, sponsoring employers are required to report in the main

[16] Observations with average match rates highest than the 95^{th} percentile are dropped from the sample. These observations roughly corresponds to plans offering match rates over \$2 dollars for each \$ contributed.

[17] Moreover, the safe harbor introduced by PPA '06 – with the maximum employer matching contribution set at 3.5 % of compensation – may appear more attractive to employers because of its lower potential cost.

5500 Form: the number of active (eligible) participants (A), the number of participants with an account balance (B), the number of retired or separated participants (receiving or not receiving benefits) (C), and the number of deceased participants (D). I define *plan participation rate* as the fraction of eligible participants with an account balance, i.e., as the ratio between the number of active (eligible) participants with an account balance – obtained by subtracting (C) and (D) from (B) – and the active (eligible) participants (A).

The data also include further detailed information on other plan characteristics, such as whether the plan is an ERISA code 401(m) arrangement, whether it is intended to comply with ERISA 402(c) code for partial fiduciary liability relief, and whether participants are allowed to self-direct (partially or totally) their individual accounts. It also provides financial information, including the amount of outstanding participant loans and the administrative fees incurred by the plan for each plan-year. The variables used in the empirical analysis are described in detail in Table 2.

For the purpose of the empirical analysis, a 401(k) plan is defined as a qualified Cash Or Deferred Arrangements under IRC sec. 401(k), that allows an employee to elect to have a portion of his or her compensation (otherwise payable in cash) contributed to a qualified *thrift-savings*, *profit sharing*, or *stock bonus (SB)/employee stock ownership plan (ESOP)*. 5500 Forms are filled following the IRS plan qualification definition, which does not distinguish among the three main types of 401(k) plan. This distinction may be however relevant, given that differences in plan design – including the practices followed by employers in matching employee deferrals – may respond to specific employer's objectives, and therefore affect the causal relationships under study. I therefore combine the information contained in the filer's plan name with information reported in the 5500 form on plan characteristics – such as whether the plan has ESOP/SB features, or an age-service/new comparability design for the allocation of profit sharing contributions – to classify qualified DC plans with a 401(k) feature as thrift-savings, profit sharing or ESOP/SB plans.[18] The empirical analysis is then performed both by 401(k) plan type and on the pooled sample of all 401(k) plans.

3.2 Descriptive statistics

Tables 3 to 5 display descriptive statistics on the main sample by plan type. Table 3 reports participation rates (upper panel) and average match rates (lower panel) by enrollment protocol (opt-in vs. opt-out) and year. As expected, participation rates are significantly higher in plans adopting auto-enrollment. The differential participation appears to be particularly large for thrift-saving plans (20-22 percentage points), as compared to

[18]Plan names including *profit sharing*, or related acronyms, and plans including a age-service/new feature are classified as profit sharing plans. Similarly, plan names including *employee stock ownership, stock bonus*, or related acronyms, and plans reporting SB or ESOP features are classified as ESOP/SB plans. The remaining 401(k) plans are classified as thrift-savings plans.

profit-sharing plans (14-18), or to ESOP/SB plans (8-9). Moreover, except for ESOP/SB plans, average match rates are found to be generally higher in plans with auto-enrollment. Table 4 reports average match rates and the incidence of auto-enrollment by plan size and year, where plans with more than 1,000 eligible employees are defined as large plans. Average match rates are significantly higher in large plans, and the gap is increasing over the observation period. They are highest in large ESOP/SB plans, while thrift-savings and profit sharing plans share similar match rates. In contrast, the incidence of auto-enrollment is higher among large thrift-savings and profit sharing plans, and among small ESOP/SB plans. Finally, Table 5 reports descriptive statistics on the variables used in the empirical analysis, by enrollment protocol, for the pooled sample.

4 Empirical Analysis

The purpose of the empirical analysis is to identify the effects of automatic enrollment and employer matching on 401(k) plan participation rates, and the effect of automatic enrollment on employer match rates. The analysis is performed at the plan level, and is limited to plans with more than 100 participants.[19] Because plan design decisions, like matching and automatic enrollment, are made at the plan level, the plan is the appropriate level of analysis.

4.1 Estimating Equations

I first specify and estimate the plan participation rate equation as a linear model with additive heterogeneity:

$$y_{it} = \beta_0 + \beta_1 x_{i1t} + \beta_2 x_{i2t} + \gamma \mathbf{x}_{i3t} + c_i + u_{it}, \qquad i = 1, 2, \ldots, n \quad t = 2, \ldots, 4 \qquad (1)$$

where y_{it} is the participation rate outcome for plan i in period t; x_{i1t} is a dummy indicating if the plan adopted an auto-enrollment protocol; x_{i2t} is a measure of the employer match rate, i.e., the ratio of employer matching (and non-matching) contributions to employee elective deferrals; $\mathbf{x}_{i3t}$ is a vector of other time-variant (invariant) plan design features and firm specific characteristics, including time dummies and other aggregate time variables; the error term includes a time-invariant plan-specific component (c_i) and an idiosyncratic component (u_{it}).

Depending on the further structure imposed on the errors – and on whether the panel data structure is exploited – equation (1) can be estimated by pooled OLS (POLS), random effects (RE), or fixed effects (FE). In the presence of unobserved confounding

[19] This implies that medium-sized plans in our sample are given the same weight of large and mega plans. By contrast, employee-level analysis is usually skewed toward plans feature and behavior of larger firms (Mitchell, Utkus, and Yang, 2006).

factors (c_i), the explanatory variables in equation (1) will be correlated with the compound error term ($v_{it} = c_i + u_{it}$) and the POLS estimator (as well as the FGLS estimator derived from a RE estimating approach) will be biased and inconsistent. By contrast, FE allows for arbitrary correlation between selection and c_i.

In my data, between 5% and 10% of the plan-year observations, depending on the type of 401(k) plan, have a participation rate equal to one. While standard panel data methods do not take into account the fractional nature of the response variable, fractional response (FR) models have been recently developed for balanced (Papke and Wooldridge, 2008) and unbalanced panel data (Wooldridge, 2010).

In unbalanced panel data settings, the conditional expectation of the fractional outcome is assumed to be of the index form:

$$E(y_{it}|\mathbf{x}_{it}, c_i) = \Phi(\mathbf{x}_{it}\beta + c_i), \qquad i = 1, 2, \ldots, n \quad t = 2, \ldots, T_i,$$

where the unobserved effect, c_i appears additively inside the standard normal cumulative distribution function, Φ. The magnitude of the estimated partial effects depends thus on the level of the covariates and of the unobserved heterogeneity. Average Partial Effects (APE) with respect to (continuous) x_{tj}, evaluated at $\mathbf{x}_t$, can be obtained by averaging the partial effects across the distribution of c_i:

$$E_c[\beta_j \phi(\mathbf{x}_t\beta + c)] = \beta_j E_c[\phi(\mathbf{x}_t\beta + c)],$$

Under the assumptions that $\mathbf{x}_{it}$ is strictly exogenous conditional on c_i, and that selection is conditionally ignorable,[20] the APEs – and, up to a positive scale factor, the β – can be identified by modeling the unobserved heterogeneity in the form of correlated random effects (Wooldridge, 2010), i.e., by allowing its conditional mean and variance to depend on the number of observations within each sub-panel T_i. The conditioning vector of the unobserved heterogeneity term, $\mathbf{w}_i$, includes the time-averaged covariates $\bar{\mathbf{x}}_i$ and the number of time periods T_i within each sub-panel. Moreover, (Wooldridge, 2010) suggests a flexible form to model the conditional variance of the heterogeneity term, which I apply in the estimation (see the Appendix for details). Using the probit link function Φ, this essentially leads to a fractional heteroskedastic probit (FHP) model that can be estimated using standard econometric software.[21] The explanatory variables included in the probit's conditional expectation at time t are $(1, \mathrm{x}_{it}, 1[T_i = 2], \ldots, 1[T_i = T], [T_i = 2]\cdot\bar{\mathbf{x}}_i, \ldots, 1[T_i = T] \cdot \bar{\mathbf{x}}_i)$, while the explanatory variables in the variance are simply the dummy variables

[20] That is: $E(y_{it}|\mathbf{x}_i, c_i, \mathbf{s}_i) = E(y_{it}|\mathbf{x}_i, c_i)$, where $\mathbf{s}_i = (s_{i1}, s_{i2}, \ldots, s_{iT})$ is a vector of selection indicators, with $s_{it} = 1$ if time period t can be used in the estimation (i.e., all the variables in equation (1) are observed for individual i at time t). This assumption implies that observing a data point in any time period cannot be systematically related to the idiosyncratic errors, u_{it}, whereas selection s_{it} at time period t is allowed to be arbitrarily correlated with $(\mathbf{x}_i, c_i)$.

[21] I use Stata `fhetprobit`, provided by (Bluhm, 2013).

$(1[T_i = 2], \ldots, 1[T_i = T-1])$. In my application, since I have $T = 4$, I define dummy variables assuming value one for plans with $T_i = 2$ and with $T_i = 3$. Plans with $T_i = 4$ act as the reference category, while those observed for only one period ($T_i = 1$) are dropped from the analysis.

Equation (1) is first estimated on unbalanced panel samples of 401(k) plans observed for at least two periods by POLS, FE, and FHP. The estimation is then repeated for each 401(k) plan type (thrift-savings, profit sharing, and ESOP/SB). Four specifications of equation (1) are employed. In specification (1), the average match rate enters linearly. In specification (2), the average match rate is replaced by a set of match rate dummies. This specification aims at detecting possible non-linearities in the match-participation relationship. The omitted category is represented by plans that do not match elective deferrals. Specification (3) – including only a match availability dummy – aims at capturing a phenomenon that was particularly relevant during the observation period: "match reinstatements" following a "match suspension" . Following the financial crisis of 2008-2009, many companies decided to suspend their match (Munnell and Quinby, 2010; Apte and Mcfarland, 2011). Starting in 2010, most of these companies reinstated their match. The data allow me to observe this match dynamics, and to exploit it as a source of identifying variation. Finally, specification (4) adds to specification (1) an interaction term between the auto-enrollment dummy and the average match rate, where the latter is taken in difference from its mean. This specification allows me to test whether more generous matching policies are associated with higher participation rates in plans with automatic enrollment.

Furthermore, to investigate the effect of automatic enrollment on average match rates, I estimate – by POLS and FE – the following equation:

$$AMRate_{it} = \beta_0 + \beta_1 Autoenroll_{it} + \gamma \mathbf{x}_{it} + c_i + u_{it}, \qquad i = 1, 2, \ldots, n \quad t = 2, \ldots, 4 \quad (2)$$

where $AMRate_{it}$ is the average match rate for plan i at time t, and $Autoenroll_{it}$ is a dummy variable taking the value one for auto-enrollment plans.

4.2 Results

The results obtained estimating equation (1) by POLS, FE, and FHP for the full sample of 401(k) plans are presented in Table 6. Tables 7, 8, and 9 report the results obtained for the subsamples of thrift-savings, profit sharing, and ESOP/SB plans, respectively.

Four main findings emerge from the POLS estimation results for the four specifications used, reported in columns 1, 4, 7, and 10 of each table, respectively. First, consistent with the descriptive statistics reported in Table 3, plans with automatic enrollment have significantly higher participation rates. On average, in the sample of all 401(k) plans, participation rates are about 16 percentage points higher in auto-enrollment plans. How-

ever, as shown in Tables 7 to 9, the magnitude of the effect varies by plan type, being highest for thrift-savings plans (17 percentage points), and lowest for ESOP/SB plans (10 percentage points). A second finding is that the average match rate is positively and significantly related to the participation rate. For the sample of all 401(k) plans, each 25 percentage point increase in the average match rate raises participation by 5.5 percentage points. Again, the magnitude of the effect is highest for thrift-savings plans (6.25 percentage points), and lowest for ESOP/SB plans (2.5 percentage point). There is also evidence of important nonlinearities in the impact of average match rates on participation: Plans whose average match rates are more than $ for $ have the highest impact on participation when compared to plans with no match. Furthermore, the availability of a match – specification (3) – increases participation rates by about 16 percent in the sample of all 401(k) plans, as well as among thrift-savings and profit sharing plans, but only by 7.5 percentage points among ESOP/SB plans. Finally, the results of estimating specification (4) suggest that the generosity of the match is not effective in increasing plan participation rates in plans with automatic enrollment.

While the POLS results represent a useful benchmark, they are likely biased, due to the potential endogeneity of matching and auto-enrollment. The bias would tend to be downward if the latter were mainly driven by the need to increase the participation rate in NHCEs in order to pass non-discrimination tests. In contrast, if employers' plan design choices were mainly driven by the desire to attract and retain a higher-quality workforce, the bias would tend to be upward. I address this issue by exploiting the panel structure of the data, i.e., by using FE and FHP panel data estimators. FE and FHP estimation results for the four specifications used – reported in columns 2-3, 5-6, 8-9, and 11-12 of each table, respectively – indicate that the impacts of both auto-enrollment and average match rates decline significantly from the POLS benchmark estimates. Nonetheless, the effects remain positive and strongly significant. However, FHP estimates generally tend to be 10-20% higher than FE estimates. This confirms the importance of taking into account the fractional nature of the participation rate.[22]

Automatic enrollment leads to a significantly higher participation rate in the full sample of 401(k) plans (6-7 percentage points), as well as in subsamples of thrift-savings plans (6-7 percentage points), of profit-sharing plans (5-6 percentage points), and of ESOP/SB plans (4 percentage points). These figures amount, respectively, to a 10, 11, 9, and 5% increase of standard enrollment plans' participation rates, as reported in Table 3. Caution should, however, be used in interpreting these results. These are likely downwardly biased estimates of the causal effects of automatic enrollment on participation rates, be-

[22]These results appear to be quite robust across specifications. Nonetheless, as a final robustness check, equation (1)) was estimated also on restricted samples including either single-employer sole 401(k) plans with more than 100 participants or single-employer sole 401(k) plans with more than 100 participants and offering a match. The results from this exercise – not reported here for the sake of brevity, and available upon request – confirm the robustness of my findings.

cause most plans apply automatic enrollment only to new hires, rather than extending auto-enrollment to all eligible participants. Despite the limitations implied by the lack of further auto-enrollment eligibility details in Form 5500 data, my results are broadly consistent with the findings provided by Madrian and Shea (2001), Choi, Laibson, Madrian, and Metrick (2004), and Beshears, Choi, Laibson, and Madrian (2008).

A further result emerging from FE/FHP estimates is that automatic enrollment is much more effective than employer matching in increasing participation rates. The impacts of average match rates remain positive and significant, but are substantially lower than those obtained by POLS: For example, each 25 percentage point increase in the average match rate would increase participation by 1.25 percentage points in the sample of all 401(k) plans, by 0.9 percentage points in the sample of profit sharing plans, and by 1.5 percentage points in the sample of thrift-savings plans.[23] The latter findings are consistent with Ippolito (2002)'s 401(k) plans theory that advocates the use of matching by employers as a workforce sorting device. In contrast, they are at odds with the findings of earlier studies that use instrumental variables (IV) to address the endogeneity of employer matching. The IV match estimates provided by Even and Macpherson (2005) and Dworak-Fisher (2011) are rather consistent with the view that a failure to account for the possible influence of employee saving preferences on employer matching may lead to an understatement of the impact of matching on employee participation. However, the internal validity of these studies, as acknowledged by these authors, may be threatened by the potential invalidity of the instruments used.

The second issue I address is how automatic enrollment affects average employer match rates. Using cross-sectional data, Soto and Butrica (2009) and Butrica and Karamcheva (2015) suggest that plans with automatic enrollment have lower (by 7-8 percentage points) match rates. However, these studies do not address the potential auto-enrollment endogeneity that could confound the estimates. In contrast, I use panel data to difference out any plan-specific characteristics that are correlated with both auto-enrollment and the level of average match rates. Estimation results from POLS and FE of the average match rate equation – equation (2) – are presented in Table 10. The POLS results – that exploit the natural cross-sectional variation in the sample of all 401(k) plans – suggest that automatic enrollment has no effect on average match rates. When repeating the analysis by plan type, though, the auto-enrollment effect exhibits some heterogeneity: It is negative and significant in profit sharing plans, and positive and significant in thrift-

[23]As previously mentioned, a difficulty with 5500 Form data is that the match rate offered by the sponsoring employer can only be measured as the ratio of employer to employee contributions. As a consequence, this average match rate might be measured imprecisely: it may be overstated, if employers contributions include non-matching contributions, or understated, if employee contributions include unmatched contributions. However, if the average match rate were systematically overstated (or understated), the FE estimator would make it possible to eliminate this bias. In any case, given the potential attenuation bias proceeding from measurement error, my results could still be considered as a lower bound of the impact of match rates on participation.

savings plans. However, when exploiting within plan over-time variation to address the potential endogeneity of auto-enrollment, the latter is generally found to have positive and significant effects on average match rates. This result is in stark contrast with the evidence provided in earlier studies, and suggests that a complementarity – rather than a trade-off – may be at work between these key 401(k) plan design features.

5 Conclusions

The evidence provided in this study sheds further light on the role of two key features of 401(k) plan design – employer matching and automatic enrollment – that are intended to have an indirect and direct impact, respectively, on participation rates. Plan participation and match rate equations are estimated on plan-level panel data taken from Form 5500 over the period 2009-2012. In line with previous studies, while both auto-enrollment and average match rates are found to have positive and significant effects, auto-enrollment is found to play a prominent role in boosting participation rates. However, in contrast with previous evidence, auto-enrollment is generally found to have a positive effect on average match rates. The latter result suggests that a complementarity – rather than a trade-off – may be at work between these key 401(k) plan design features, and is in contrast with earlier literature findings.

Several data-related caveats are worth nothing while interpreting my results. First, information on the plan match formula is not available, and the match rate has to be inferred from the ratio of employer to employee contributions. Second, employers sponsoring a plan offering automatic enrollment do not report when this provision was adopted, nor if it only applies to new hires. Finally, the data do not include information on average time-varying employees' characteristics (such as education, salary, and demographics) that could help explain participation and match rates dynamics at the plan level. Despite these data limitations, this study contributes to the literature by addressing internal and external validity threats that raise concern in many earlier studies, and offers valuable information to plan sponsors and policy-makers.

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Table 1. Studies on the impact of matching/auto-enrollment on 401(k) plan participation

Study	Data	N	Estimation method	Dependent variable	Employer match definition	Marginal effects
Individual-level cross-sectional survey data						
Bassett, Fleming, and Rodrigues (1998)	Current Population Survey, 1993	5,658	LPM	Participation Dummy	Employer Match Dummy	0.09**
Even and Macpherson (2005)	Current Population Survey, 1993	3,884	Probit	Participation Dummy	Employer Match Dummy	0.077**
		3,884	Bivariate Probit	Participation Dummy	Employer Match Dummy	0.237** - 0.328**
		3,884	IV LPM	Participation Dummy	Employer Match Dummy	0.2384 - 0.5**
Engelhardt and Kumar (2007)	Health and Retirement Survey, 1991	1,042	IV Probit	Participation Dummy	Match Rate	0.183** - 0.22**
Plan-level cross-sectional survey data						
Dworak-Fisher (2011)	National Compensation Survey Plans, 2002/2003	587	BQMLE	Participation Rate	Log(Match Rate (%)), Log(Max. Match (%))	0.0396** - 0.0580**, 0.0013 - 0.4264**
		587	IV BQMLE	Participation Rate	Log(Match Rate (%))	-0.07 - 0.4264**
Butrica and Karamcheva (2012)	National Compensation Survey Plans, 2010/2011	1,200	LPM	Participation Rate (%)	Max. Match (%)	0.161
Plan-level cross-sectional administrative data						
GAO (General Accounting Office)	IRS Form 5500 Plans, 1992	4,006	OLS	Participation Rate	Average Match Rate Dummies	0.1035** - 0.3341**
Individual-level cross-sectional company data						
Clark and Schieber (1998)	19 Watson Wyatt Plans, 1994	59,203	Logit	Participation Dummy	Match Rate Dummies	0.28** - 0.47**
Clark, Goodfellow, Schieber, and Warwick (2000)	87 Watson Wyatt Plans, 1995	152,914	Logit	Participation Dummy	Match Rate (%)	0.03**
Huberman, Iyengar, and Jiang (2005)	647 Vanguard Plans, 2001	793,794	LPM, Probit	Participation Dummy	Match Rate up to 2% of Pay (%)	0.12**
Beshears, Choi, Laibson, and Madrian (2010)	9 Hewitt Auto-enrollment Plans, 2002-2005	44,279	LPM	Participation Dummy	Max. Match (%)	2.2** - 2.78**
	6 Hewitt Auto-enrollment Plans, 2002-2005	35,895	LPM	Participation Dummy	Max. Match (%)	1.778** - 3.752**
Plan-level cross-sectional company data						
Papke and Poterba (1995)	54 IRS Form 5500 Plans, 1987	37	OLS	Participation Rate	Match Rate	0.255**
		38	OLS	Participation Rate	Match Rate Dummies	0.42** - 0.71**
Mitchell, Utkus, and Yang (2007)	507 Vanguard Plans, 2001	507 (NHCE)	OLS	Participation Rate (%)	Match Rate up to 3% of Pay, Max. Match (%)	0.098**, 0.844**
		474 (HCE)	OLS	Participation Rate	Match Rate up to 3% of Pay, Max. Match (%)	0.049**, 0.281
Plan-level longitudinal administrative data						
Papke (1995)	IRS Form 5500 Plans, 1986-1987	8,672	OLS	Participation Rate	Average Match Rate Dummies	0.039** - 0.21**
		5,518	Fixed Effects OLS	Participation Rate	Average Match Rate Dummies	-0.01 - 0.014
Individual-level longitudinal company data						
Kusko, Poterba, and Wilcox (1998)	Buck Consultants Company X Plan, 1988-1991	12,000	Descriptive Statistics	Participation Rate Change	Match Rate Change (%)	No Change in Participation
Choi, Laibson, Madrian, and Metrick (2002)	Hewitt Company E Plan, 1996-2000	n.a.	Cox Proportional Hazard	Participation Hazard Ratio	Match Threshold Change Dummy	0.797
	Hewitt Company F Plan, 1998-2000	n.a.	Cox Proportional Hazard	Participation Hazard Ratio	Match Introduction Dummy	1.4642**
Beshears, Choi, Laibson, and Madrian (2010)	Hewitt Company A Auto-enrollment Plan, 2002-2003	645	LPM, Probit	Participation Dummy	Match Cohort Dummy	0.067** - 0.06**, 0.065** - 0.054**

Notes: ** significant at 1% * significance at 5%.

Table 2. Description of Form 5500 PPP research files variables

Variables	Type	Description
Participation rate	Ratio	Active (eligible) participants accounts/Active (eligible) participants
Plan design features		
Avg. match rate	Ratio	Average match rate = Total employer contributions/Total employee deferrals
Automatic Enrollment	Dummy	Plan provides for automatic enrollment of either newly hired or all employees
Employer match available	Dummy	Employer offers matching contributions (=1 if Total employer contributions>0)
Avg. match rate: 0.01-0.50	Dummy	Average match rate in the 0.01-0.50$ range for each $ of employee deferrals
Avg. match rate: 0.51-1.00	Dummy	Average match rate in the 0.51-1.00$ range for each $ of employee deferrals
Avg. match rate: 1.01-1.50	Dummy	Average match rate in the 0.51-1.00$ range for each $ of employee deferrals
Avg. match rate: > 1.50	Dummy	Average match rate above 1.50$ for each $ of employee deferrals
Sole plan	Dummy	Plan considered as the sole plan of a sponsor
Erisa 404 (c) plan	Dummy	Plan intended to comply with Erisa 404(c) (fiduciary liabilities relief)
Erisa 401 (m) plan	Dummy	Plan offers matching contributions and/or after-tax employee deferrals
No self-directed account	Dummy	Participants cannot direct the investment of a portion of their account assets
Partially self-directed account	Dummy	Participants can direct the investment of a portion of their account assets
Totally self-directed account	Dummy	Participants can direct the investment of all their account assets
Default investment accounts	Dummy	Plan uses *default investment accounts* for participants who fail to self-direct
Participant-directed brokerage option	Dummy	Participant-directed brokerage accounts provided as an investment option
Employer contrib. in employer securities	Dummy	Plan requiring all/part of employer contributions invested in employer securities
Corrective distribution	Dummy	A corrective distribution for excess deferrals has been made during the plan-year
Plan termination adopted	Dummy	A resolution to terminate the plan been adopted during this or any prior plan-years
Active (eligible) participants: $> 1{,}000$	Dummy	More than 1,000 participants eligible to enrollment
Collective bargained plan	Dummy	Plan established under a collectively bargaining agreement
Profit sharing or ESOP specific plan design features		
ESOP: Leveraged	Dummy	ESOP borrowing fund to acquire employer's stocks
ESOP: Non leveraged	Dummy	ESOP not borrowing fund to acquire employer's stocks
ESOP: S corporation	Dummy	ESOP sponsor is a S corporation for the tax-year
Age-service/New-comparability plan	Dummy	Allocations based on: age/service or participant class. (new comparability)
Financial Variables		
Avg. salary deferral, per participant	1,000$	Average employee deferral, per participant
Avg. employer contribution, per participant	1,000$	Average employer contribution, per participant
Avg. assets, per participant	1,000$	Average assets, per participant
Avg. loan, per participant	1,000$	Average loan, per participant
Avg. fee, per participant	1,000$	Average administrative fees, per participant

Table 3. Participation and match rates (%) by plan type, enrollment protocol, and year

	Panel year									
	2009		2010		2011		2012		Pooled	
	Opt-in	Auto	Opt-in	Auto	Opt-in	Auto	Opt-in	Auto	Opt-in	Auto
Participation by plan type:										
Thrift-Savings	63	82	62	82	62	82	61	83	62	82
Profit Sharing	72	85	71	85	70	86	70	86	71	86
ESOP/SB	82	91	83	91	83	91	83	91	83	91
Total	66	83	65	83	65	84	64	484	65	84
Avg. match by plan type:										
Thrift-Savings	34	39	34	39	35	41	36	41	35	40
Profit Sharing	47	50	46	52	47	53	48	52	47	52
ESOP/SB	57	51	56	53	60	55	63	55	59	54
Total	39	42	38	43	40	44	41	45	39	43

Notes: Rates computed on an unbalanced sample including single-employer 401(k) plans with more than 100 participants.

Table 4. Match and auto-enrollment rates (%) by plan type, plan size, and year

	Panel year									
	2009		2010		2011		2012		Pooled	
	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large
Avg. match by plan type:										
Thrift-Savings	11	21	16	28	18	31	20	34	16	29
Profit Sharing	9	23	13	31	15	33	17	35	14	30
ESOP/SB	9	30	16	42	19	46	22	50	17	42
Total	10	22	15	29	17	33	19	35	15	30
Auto-enrollment by plan type:										
Thrift-Savings	34	39	34	39	35	41	36	41	35	40
Profit Sharing	47	50	46	52	47	53	48	52	47	52
ESOP/SB	57	51	56	53	60	55	63	55	59	54
Total	39	42	38	43	40	44	41	45	39	43

Notes: Rates computed on an unbalanced sample including single-employer 401(k) plans with more than 100 participants.

Table 5. Descriptive statistics, by type of 401(k) plan and enrollment protocol

	Thrift-Savings			Profit Sharing			ESOP/SB			All		
	Opt-in	**Auto**	**Total**	**Opt-in**	**Auto**	**Total**	**Opt-in**	**Auto**	**Total**	**Opt-in**	**Auto**	**Total**
Plan participation												
Participation rate	0.62	0.82	0.65	0.71	0.86	0.73	0.83	0.91	0.85	0.65	0.84	0.68
Eligible participants	706.6	1163.3	787.0	386.2	650.7	424.6	11414.3	11075.1	11310.2	734.9	1298.0	829.3
Eligible participants with account balance	372.5	938.2	472.1	235.4	552.4	281.3	8502.3	9886.4	8927.1	431.1	1082.5	540.3
Financial variables												
Avg. salary deferral per participant (1,000$)	4.04	4.24	4.08	3.79	3.96	3.82	4.65	5.33	4.86	3.96	4.19	4.00
Avg. employer contribution per participant (1,000$)	1.36	1.64	1.41	1.89	1.98	1.90	2.53	2.98	2.67	1.56	1.78	1.60
Sole plan	0.85	0.77	0.84	0.91	0.86	0.90	0.53	0.33	0.47	0.87	0.78	0.85
Loans available	0.72	0.85	0.74	0.66	0.79	0.68	0.81	0.93	0.85	0.70	0.83	0.72
Avg. loan per participant (1,000$)	1.02	1.27	1.07	0.94	1.20	0.97	1.74	2.25	1.89	1.00	1.28	1.05
Avg. assets per participant (1,000$)	52.9	64.6	54.9	61.5	69.3	62.7	110.1	127.7	115.5	56.6	67.8	58.5
Avg. administrative fee per participant (100$)	0.78	0.68	0.77	0.99	0.85	0.97	0.94	0.79	0.89	0.86	0.73	0.84
Plan design features:												
Auto-enrollment and matching												
Automatic enrollment	0	1	0.18	0	1	0.15	0	1	0.31	0	1	0.17
Employer match available	0.79	0.84	0.79	0.81	0.85	0.81	0.92	0.97	0.94	0.79	0.85	0.80
Avg. match rate	0.35	0.38	0.35	0.48	0.46	0.47	0.56	0.57	0.56	0.40	0.41	0.40
Avg. match rate: [0.01-0.50]	0.52	0.55	0.53	0.43	0.49	0.44	0.43	0.46	0.44	0.49	0.53	0.49
Avg. match rate: [0.51-1.00]	0.21	0.23	0.22	0.24	0.23	0.24	0.36	0.40	0.37	0.23	0.23	0.23
Avg. match rate: [1.01-1.50]	0.038	0.048	0.039	0.092	0.099	0.093	0.085	0.095	0.088	0.057	0.064	0.058
Avg. match rate: [>1.50]	0.014	0.012	0.014	0.049	0.029	0.046	0.042	0.017	0.034	0.027	0.017	0.025
Plan investments												
Partially self-directed account	0.013	0.015	0.013	0.034	0.025	0.033	0.44	0.38	0.42	0.026	0.028	0.026
Totally self-directed account	0.97	0.98	0.97	0.94	0.96	0.94	0.50	0.60	0.53	0.95	0.96	0.95
Self-directed brokerage option	0.054	0.11	0.063	0.098	0.15	0.10	0.13	0.31	0.19	0.070	0.13	0.079
Default investment account	0.62	0.95	0.68	0.59	0.94	0.64	0.39	0.93	0.56	0.61	0.95	0.66
Employer contrib. in employer securities	0.0030	0.0076	0.0038	0.0015	0.0030	0.0018	0.20	0.21	0.20	0.0050	0.012	0.0062
Other plan characteristics												
Erisa 404 (c) plan	0.89	0.95	0.90	0.81	0.91	0.83	0.71	0.89	0.77	0.86	0.94	0.87
Erisa 401 (m) plan	0.89	0.93	0.90	0.84	0.89	0.85	0.89	0.96	0.91	0.88	0.92	0.88
Corrective distributions made	0.30	0.38	0.32	0.26	0.34	0.27	0.23	0.29	0.25	0.29	0.36	0.30
Sponsor member of a controlled group	0.30	0.38	0.32	0.26	0.33	0.27	0.46	0.64	0.52	0.29	0.38	0.31
Master plan	0.83	0.77	0.82	0.83	0.80	0.83	0.13	0.052	0.11	0.82	0.75	0.81
Collectively bargained plan	0.052	0.068	0.055	0.018	0.030	0.019	0.15	0.18	0.16	0.041	0.060	0.045
Plan termination adopted	0.0024	0.0017	0.0023	0.0026	0.0025	0.0026	0.0022	0.00100	0.0018	0.0024	0.0019	0.0024
Date of plan establishment												
Between 1982 and 1999	0.61	0.64	0.62	0.56	0.56	0.56	0.62	0.51	0.58	0.60	0.61	0.60
After 1999	0.31	0.25	0.30	0.23	0.17	0.23	0.10	0.14	0.11	0.28	0.22	0.27
ESOP-specific plan design features												
ESOP: Leveraged	-	-	-	-	-	-	0.18	0.13	0.16	0.0023	0.0038	0.0026
ESOP: Leverageable	-	-	-	-	-	-	0.82	0.87	0.84	0.011	0.025	0.013
ESOP: S corporation	-	-	-	-	-	-	0.13	0.062	0.11	0.0017	0.0018	0.0018
Profit Sharing-specific plan design features												
Age/service - New comparability	-	-	-	0.23	0.20	0.22	0.050	0.043	0.048	0.080	0.060	0.076
Observations	110,148	23,544	133,692	60,420	10,247	70,667	2,265	1,003	3,268	172,833	34,794	207,627

Notes: Summary statistics computed on the pooled unbalanced panel including single-employer 401(k) plans with more than 100 participants, observed for at least two periods.

Table 6. Participation rate equation: estimation results for all 401(k) plans

	(1)			(2)			(3)			(4)		
	POLS	**FE**	**FHP**	**POLS**	**FE**	**FHP**	**POLS**	**FE**	**FHP**	**POLS**	**FE**	**FHP**
Automatic enrollment	0.161**	0.060**	0.067**	0.160**	0.060**	0.068**	0.158**	0.060**	0.068**	0.168**	0.06**	0.066**
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
Avg. match rate	0.224**	0.041**	0.049**							0.243**	0.045**	0.052**
	(0.002)	(0.001)	(0.002)							(0.002)	(0.002)	(0.002)
Avg. match rate: [0.01-0.50]				0.120**	0.023**	0.020**						
				(0.002)	(0.001)	(0.001)						
Avg. match rate: [0.51-1]				0.206**	0.040**	0.038**						
				(0.003)	(0.001)	(0.002)						
Avg. match rate: [1,01-1.50]				0.310**	0.049**	0.054**						
				(0.003)	(0.002)	(0.003)						
Avg. match rate: [1.51-2.00]				0.319**	0.051**	0.057**						
				(0.004)	(0.003)	(0.005)						
Employer match available							0.163**	0.026**	0.024**			
							(0.002)	(0.001)	(0.001)			
Autoenrollment×Avg. match										−0.124**	−0.026**	−0.026**
										(0.004)	(0.003)	(0.006)
Observations	207,627											

Notes: Dependent variable is plan participation rate (defined as a proportion). All specifications include controls for time-variant plan specific characteristics and year dummies. Pooled OLS (POLS) specifications include controls for time-invariant firm specific characteristics. Fractional heteroschedastic probit (FHP) specifications include controls for within-plan averages of time-varying plan characteristics. Estimates reported for Fractional Heteroscedastic Probit (FHP) are Average Partial Effects (APEs) and corresponding delta-method standard errors. All specifications are estimated on an unbalanced panel including single-employer 401(k) plans with more than 100 participants, observed for at least two periods. Clustered standard errors in parentheses. ** Significant at the 1% significance level.

Table 7. Participation rate equation: estimation results for thrift-savings plans

	(1)			(2)			(3)			(4)		
	POLS	**FE**	**FHP**	**POLS**	**FE**	**FHP**	**POLS**	**FE**	**FHP**	**POLS**	**FE**	**FHP**
Automatic enrollment	0.171**	0.063**	0.071**	0.171**	0.063**	0.071**	0.171**	0.063**	0.072**	0.168**	0.062**	0.072**
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.005)	(0.002)	(0.002)
Avg. match rate	0.251**	0.052**	0.060**							0.272**	0.056**	0.061**
	(0.003)	(0.002)	(0.003)							(0.003)	(0.003)	(0.003)
Avg. match rate: [0.01-0.50]				0.123**	0.024**	0.021**						
				(0.003)	(0.001)	(0.001)						
Avg. match rate: [0.51-1.00]				0.210**	0.041**	0.040**						
				(0.003)	(0.002)	(0.002)						
Avg. match rate: [1.01-1.50]				0.333**	0.053**	0.059**						
				(0.004)	(0.003)	(0.005)						
Avg. match rate: [>1.50]				0.348**	0.060**	0.069**						
				(0.006)	(0.004)	(0.007)						
Employer match available							0.162**	0.026**	0.024**			
							(0.003)	(0.001)	(0.002)			
Autoenrollment×Avg. match										−0.127**	−0.024**	−0.009
										(0.004)	(0.005)	(0.009)
Observations	133,692											

Notes: Dependent variable is plan participation rate (defined as a proportion). All specifications include controls for time-variant plan specific characteristics and year dummies. Pooled OLS (POLS) specifications include controls for time-invariant firm specific characteristics. Fractional heteroschedastic probit (FHP) specifications include controls for within-plan averages of time-varying plan characteristics. Estimates reported for Fractional Heteroscedastic Probit (FHP) are Average Partial Effects (APEs) and corresponding delta-method standard errors. All specifications are estimated on an unbalanced panel including single-employer 401(k) thrift-savings plans with more than 100 participants, observed for at least two periods. Clustered standard errors in parentheses. ** Significant at the 1% significance level.

Table 8. Participation rate equation: estimation results for profit sharing plans

	(1)			(2)			(3)			(4)		
	POLS	**FE**	**FHP**	**POLS**	**FE**	**FHP**	**POLS**	**FE**	**FHP**	**POLS**	**FE**	**FHP**
Automatic enrollment	0.140**	0.055**	0.062**	0.138**	0.054**	0.062**	0.133**	0.055**	0.062**	0.148**	0.055**	0.062**
	(0.003)	(0.002)	(0.004)	(0.003)	(0.002)	(0.004)	(0.003)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)
Avg. match rate	0.194**	0.030**	0.036**							0.219**	0.034**	0.040**
	(0.003)	(0.002)	(0.003)							(0.003)	(0.002)	(0.003)
Avg. match rate: [0.01-0.50]				0.110**	0.023**	0.019**						
				(0.004)	(0.002)	(0.002)						
Avg. match rate: [0.51-1.00]				0.196**	0.037**	0.034**						
				(0.004)	(0.002)	(0.003)						
Avg. match rate: [1.01-1.50]				0.286**	0.044**	0.047**						
				(0.004)	(0.003)	(0.004)						
Avg. match rate: [>1.50]				0.293**	0.043**	0.045**						
				(0.005)	(0.004)	(0.005)						
Employer match available							0.162**	0.026**	0.023**			
							(0.004)	(0.002)	(0.002)			
Autoenrollment×Avg. match										−0.119**	−0.029**	−0.043**
										(0.006)	(0.005)	(0.009)
Observations	70,667											

Notes: Dependent variable is plan participation rate (defined as a proportion). All specifications include controls for time-variant plan specific characteristics and year dummies. Pooled OLS (POLS) specifications include controls for time-invariant firm specific characteristics. Fractional heteroschedastic probit (FHP) specifications include controls for within-plan averages of time-varying plan characteristics. Estimates reported for Fractional Heteroscedastic Probit (FHP) are Average Partial Effects (APEs) and corresponding delta-method standard errors. All specifications are estimated on an unbalanced panel including single-employer 401(k) profit sharing plans with more than 100 participants, observed for at least two periods. Clustered standard errors in parentheses. ** Significant at the 1% significance level.

Table 9. Participation rate equation: estimation results for ESOP/SB plans

	(1)			(2)			(3)			(4)		
	POLS	**FE**	**FHP**	**POLS**	**FE**	**FHP**	**POLS**	**FE**	**FHP**	**POLS**	**FE**	**FHP**
Automatic enrollment	0.100**	0.036**	0.040**	0.100**	0.036**	0.040**	0.101**	0.036**	0.040**	0.108**	0.042	0.042**
	(0.011)	(0.007)	(0.009)	(0.019)	(0.007)	(0.009)	(0.011)	(0.007)	(0.009)	(0.019)	(0.025)	(0.010)
Avg. match rate	0.102**	0.039**	0.042**							0.114**	0.015	0.045**
	(0.011)	(0.008)	(0.012)							(0.011)	(0.014)	(0.012)
Avg. match rate: [0.01-0.50]				0.044*	0.009	0.005						
				(0.021)	(0.009)	(0.010)						
Avg. match rate: [0.51-1.00]				0.090**	0.027**	0.023**						
				(0.022)	(0.010)	(0.010)						
Avg. match rate: [1.01-1.50]				0.127**	0.041**	0.041**						
				(0.023)	(0.012)	(0.016)						
Avg. match rate: [>1.50]				0.139**	0.050**	0.050**						
				(0.027)	(0.016)	(0.020)						
Employer match available							0.075**	0.014	0.009			
							(0.021)	(0.009)	(0.009)			
Autoenrollment×Avg. match										−0.049**	−0.007	−0.023
										(0.0188)	(0.024)	(0.024)
Observations	3,268											

Notes: Dependent variable is plan participation rate (defined as a proportion). All specifications include controls for time-variant plan specific characteristics and year dummies. Pooled OLS (POLS) specifications include controls for time-invariant firm specific characteristics. Fractional heteroschedastic probit (FHP) specifications include controls for within-plan averages of time-varying plan characteristics. Estimates reported for Fractional Heteroscedastic Probit (FHP) are Average Partial Effects (APEs) and corresponding delta-method standard errors. All specifications are estimated on an unbalanced panel including single-employer 401(k) ESOP/SB plans with more than 100 participants, observed for at least two periods. Clustered standard errors in parentheses. ** Significant at the 1% significance level.

Table 10. Avg. match rate equation: estimation results by type of 401(k) plan

	Thrift-Savings		**Profit Sharing**		**ESOP/SB**		**All**	
	POLS	**FE**	**POLS**	**FE**	**POLS**	**FE**	**POLS**	**FE**
Automatic enrollment	0.012**	0.011**	−0.026**	0.017**	0.025	−0.015	0.000	0.013**
	(0.004)	(0.002)	(0.007)	(0.005)	(0.025)	(0.017)	(0.004)	(0.002)
Observations	133,692		70,667		3,268		207,627	

Notes: Dependent variable is the average match rate. All specifications include controls for time-variant plan specific characteristics and year dummies. Pooled OLS (POLS) specifications include controls for time-invariant firm specific characteristics. All specifications are estimated on an unbalanced panel including single-employer 401(k) plans with more than 100 participants, observed for at least two periods. Clustered standard errors in parentheses. ** Significant at the 1% significance level.

Appendix

The fractional response model for unbalanced panels is (Wooldridge, 2010):

$$E(y_{it}|\mathbf{x}_{it}, c_i) = \Phi(\mathbf{x}_{it}\beta + c_i), \qquad i = 1, 2, \ldots, n \quad t = 1, \ldots, T, \tag{A.1}$$

Unobserved heterogeneity is modeled including in the conditioning vector $\mathbf{w}_i$ time-averaged covariates $\bar{\mathbf{x}}_i$ and the number of time periods T_i:

$$E(c_i|\mathbf{w}_i) = \sum_{r=1}^{T} \psi_r 1[T_i = r] + \sum_{r=1}^{T} 1[T_i = r] \cdot \bar{\mathbf{x}}_i \xi_r, \tag{A.2}$$

where the intercept and slopes are allowed to vary across T_i. The conditional variance:

$$Var(c_i|\mathbf{w}_i) = \exp\Big(\tau + \sum_{r=1}^{T-1} 1[T_i = r]\omega_r\Big),$$

is also allowed to vary with T_i, being τ for the base group ($T_i = T$), and ω_r for the other groups. Assuming a normal distribution for c_i conditional on $\mathbf{w}_i$, an estimating equation can be obtained as a response probability:

$$Pr(y_{it} = 1|\mathbf{x}_{it}, \mathbf{w}_i) = \Phi\Big[\frac{\mathbf{x}_{it}\beta + \sum_{r=1}^{T} \psi_r 1[T_i = r] + \sum_{r=1}^{T} 1[T_i = r] \cdot \bar{\mathbf{x}}_i \xi_r}{\exp(\sum_{r=2}^{T} 1[T_i = r]\omega_r)^{\frac{1}{2}}}\Big]. \tag{A.3}$$

The APEs can therefore be estimated – for continuous $\mathbf{x}_t$ – as:

$$\widehat{APE}(\mathbf{x}_t) = \hat{\beta}_j\Big\{N^{-1}\sum_{i=1}^{N} \phi\Big[\frac{\mathbf{x}_t\hat{\beta} + \sum_{r=1}^{T} \hat{\omega}_r 1[T_i = r] + \sum_{r=1}^{T} 1[T_i = r] \cdot \bar{\mathbf{x}}_i \hat{\xi}_r}{\exp(\sum_{r=2}^{T} 1[T_i = r]\hat{\omega}_r)^{\frac{1}{2}}}\Big]\Big\}. \tag{A.4}$$

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