Optimal Default Retirement Saving Policies: Theory and Evidence from OregonSaves

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Abstract

I study the optimal default saving rate in automatic enrollment retirement saving plans. If individuals tend to procrastinate to make an active decision, the optimal default rate should be high to encourage people to opt out of the default. If individuals tend to actively undersave, the optimal default rate should be low to encourage people to stay at the default. Using an exogenous increase in the default savings rate in OregonSaves, the first state-sponsored auto-enrollment plan in U.S., I estimate individual adherence to the default rate. Combining individual-level administrative data with survey data, I suggest that the optimal default savings rate 8%.

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1 Introduction

A large literature has documented that automatically enrolling individuals into a retirement plan significantly increases their savings. Moreover, a substantial fraction of participants passively save at the default savings rate determined by the plan designer. Automatic enrollment and the default savings rate are considered to be cost-effective policy tools to help individuals better allocate resources over the life cycle and potentially improve their lifetime welfare. This argument has led to a widespread adoption of automatic enrollment in retirement plans around the world. Although many studies have found a causal effect that defaulting individuals into a predetermined savings rate effectively increases savings, little is known about the welfare effects of the default savings rate.

In this paper, I theoretically analyze and empirically identify the welfare effects of the default savings rate. I then provide an explicit formula for the optimal default savings rate that maximizes individual welfare. A growing body of literature on optimal defaults suggests that, when individuals tend to procrastinate to make an active savings decision, setting the default savings rate at an undesirable level can compel individuals to opt out of the default rate and actively select a non-default preferred rate (Carroll et al., 2009; Goldin and Reck, 2018). In other words, the primary welfare effect of the default savings rate is to protect individuals from *inaction* caused by procrastination, status quo bias, or inattention.

This argument is based on a key assumption that individuals would actively choose a non-default preferred rate that maximizes their lifetime utility if they decide to opt out of the default rate. A growing literature in behavioral economics and household finance, however, suggests that individuals might underestimate the amount of retirement savings they need due to financial illiteracy, misinformation, or myopia.

Motivated by these findings, this paper proposes an additional welfare effect of the default savings rate, namely, to correct protect individuals from *undersaving*. The distinction between inaction and undersaving is of interest because the two types of behavioral biases have opposite implications for the optimal default savings rate. If individuals tend to procrastinate rather than making an active decision, it might be welfare-improving to set the default rate at an undesirable level to compel individuals to opt out of the default rate and choose a non-default savings rate that maximizes their life cycle utility. In contrast, if the non-default preferred rate that individuals actively choose does not maximize their life cycle utility, it might be welfare-improving to set the default rate at a desirable level to encourage individuals to stay at the default rate.

To understand how the optimal level of the default savings rate is shaped by its welfare effects when correcting the two types of behavioral biases, I propose a unified framework that incorporates both types of behavioral biases. The behavioral biases arise because individuals and the policymaker maximize individual utility differently. Individuals rely on their *perception* of how their lifetime utility should be modeled. To maximize their perceived utility, commonly referred to as decision utility, individuals either passively accept the default savings rate or actively elect a non-default preferred savings rate. Given individual binary choices of either staying or opting out of the default rate, the policymaker with more information or who is more forward-looking than individuals maximizes the normative utility. That describes the *reality* of how individual choices actually affect their lifetime welfare.

Based on the unified welfare framework, I derive a formula for the optimal default savings rate as a function of reduced-form statistics that can be empirically identified. The traditional approach to such welfare and optimal policy questions usually requires structural estimation of an underlying model's primitives, and then a numerical simulation of the effects of policy changes. I instead identify a set of sufficient statistics directly from exogenous policy variations and survey responses. These sufficient statistics measure how individuals respond to different levels of the default savings rate by opting out of the defaults, and how their responses affect their lifetime welfare.

The welfare analysis and the sufficient statistic formula proposed in this paper differ from the traditional approach because my approach does not rely on specific underlying behavioral models of why the default options affect individual behavior. I instead directly characterize how individual behavior impacts their welfare. This approach allows my welfare analysis to incorporate a range of underlying behavioral models that explain the default effect on individual behavior. Additionally, since the sufficient statistics in the formula for the optimal default savings rate measure individual responsiveness to the default rate and individual revealed preference, my approach provides a non-paternalistic method to incorporate behavioral biases into the optimal design of default saving policy.

I implement the formula for the optimal default savings rate empirically by estimating three sets of key statistics. The first are two semi-elasticities measuring how individuals react to different levels of the default savings rate at an aggregate level. Using the exogenous increase in the default savings rate in the first state-sponsored retirement plan in U.S. launched in 2017, OregonSaves, I find that 12% of passive savers no longer stayed at the default rate as the default rate increased by one percentage point. Additionally, using data from Beshears et al. (2012), I find that 13% of active savers chose to stay at the default rate as the default rate increased by one percentage point.

While extensive previous research has examined the effect of default contributions, the causal effect of the default savings rate on saving behavior remains largely unclear due to data limitations. Previous studies dating back to Madrian and Shea (2001) have relied on data from employer-sponsored retirement plans where employers often match employee contributions to encourage employees to save. The presence of employer matching confounds the impact of the default rate on saving behavior, as employees' saving decisions are now influenced by both the default rate and employer matching. Given that the state-sponsored retirement plan, OregonSaves, does not allow employer matching, it provides a unique opportunity to tease out the causal effect of the default savings rate on retirement savings.

The second set of statistics are revealed time preferences to infer whether individuals would actively undersave if they were to opt out of the default rate. These statistics reveal the extent to which the default savings rates improves individual welfare by protecting them from actively undersaving. If individuals are unlikely to actively undersave, the welfare effect of correcting undersaving is dominated by the opposite welfare effect of correcting inaction. I conduct an online survey to elicit the time preferences of OregonSaves-eligible workers, in which I find that on average workers weakly prefer spending most of their income now over spreading out the income between now and the future.

The third statistic is the average perceived cost of opting out of the default savings rate. This statistic reflects the extent to which the default savings rate promotes individual welfare by protecting them from inaction. Choukhmane (2018) estimates that on average individuals believe that opting out of the default rate costs about $250. This estimate of the perceived opt-out cost suggests that, instead of spending $250 from public funds to compensate workers for voluntarily selecting their non-default preferred rates, a policymaker can avoid the public expenditure while achieving the same goal by setting the default rate optimally. Plugging the point estimates into the optimal formula, I find the optimal default savings rate to be 8%.

Contributions to the Literature. The welfare analysis proposed in this paper is related to three strands of literature. First, the optimal design of default retirement saving policies – the default savings rate in particular – has been a focus in previous research. Based on some early discussions about the welfare impact of the default rate (Thaler and Sunstein, 2003; Carroll et al., 2009), Bernheim et al. (2015) provided the first explicit guidance that the optimal default savings rate should be set at the employer matching cap in an employer-sponsored retirement plan. My analysis and the formula for the optimal default savings rate complement Bernheim et al. (2015), as I evaluate the optimal default without employer matching. I also develop the first sufficient statistics formula for the optimal default rate that directly connects the causal effect of the default rate with the welfare analysis.

The present paper also contributes to the literature on a sufficient statistics approach for optimal public policy starting with Saez (2002). I extend the applicability of the sufficient statistics approach to "nudge" policies, and in particular the default retirement saving rate. Farhi and Gabaix (2020) discussed optimal nudges in taxation, while I focus on optimal nudges in the context of default saving policies.

The present paper also sheds light on two long-standing questions in household finance. The first question is why a substantial fraction of American households saves so little. Hubbard et al. (1995) and Scholz et al. (2006) argue that the explanation largely lies in asset-based and means-tested welfare programs and Social Security benefits. Here I provide an alternative explanation: one reason people do not save is because they are not *automatically* enrolled in a savings plan. The second question I address pertains to the optimal level of savings. There is little consensus on the optimal level of retirement savings, given the substantial heterogeneity in health, expected life expectancy, retirement lifestyle, and family structure across the population. Instead of thinking about individuals' optimal level of savings, I provide a new perspective stemming from social welfare. Retirees lacking sufficient personal savings have to rely on social safety net programs which increase the fiscal burden imposed on all taxpayers to finance these social programs. From a policy perspective, social welfare is maximized when the majority of people who can afford to save do so, leaving means-tested welfare programs to support only those people who cannot afford to save.

The rest of this paper is organized as follows. Section 2 describes the institutional background of the OregonSaves program and provides descriptive statistics for the first two years of the program as of June 2019. Section 3 discusses the welfare impact of the default rate in a sufficient statistic framework and presents an explicit formula of the optimal default rate. Section 4 describes the identification strategies and estimation results of the key statistics in the optimal default formula using OregonSaves administrative and survey data. In Section

5, I calculate the optimal default rate using the estimation results from Section 4. Section 6 concludes.

2 An Overview of OregonSaves

In this section, I provide the institutional background and some preliminary empirical evidence on the first state-based mandatory retirement savings program in the United States, called OregonSaves.

2.1 Institutional Background

The 2015 passage of Oregon House Bill 2960 set into motion the creation of the OregonSaves program, the first U.S. state-sponsored retirement savings program. The Oregon Retirement Savings Board was given statutory authority to research and design the plan, with a target launch date of July 2017. OregonSaves requires that all private-sector employers including non-profit organizations either offer their own retirement plans or enroll their employees in OregonSaves. Besides Oregon, nine states have passed the legislation to establish a state-sponsored retirement plan to date. Table 1 provides information on the state-sponsored plans across the states.

OregonSaves is structured as a Roth Individual Retirement Account (IRA), with automatic enrollment, a default (after-tax)savings rate of 5%, and employee-only contributions. Once an employer registers and provides OregonSaves with employees data, employees enter a 30-day enrollment period during which time their identity is verified and employees may choose to opt out. A Roth account[1] is created at the end of the enrollment period for each employee that has not opted out and whose identity is successfully verified. Enrollment in OregonSaves sets contributions levels at a 5% default rate, though employees can choose

[1] Contributions to a Roth account are not tax free, while qualified withdrawals and earnings in the account are tax-free.

to save at different rates (up to 100% of pay), or opt out at any time. By default, the first $1,000 contributed into each participant's OregonSaves account is invested in a money market account. When a saver's account balance reaches $1,000, subsequent contributions default into an age-appropriate target date fund.

OregonSaves differs from conventional employer-sponsored retirement plans such as 401(k) or 403(b) plans in two key ways. First, OregonSaves participants may access their contributions invested in the money market account without penalty. The OregonSaves account is a combination of an emergency savings account (first $\$1,000$ withdrawal without penalty), and a retirement savings account (long-term investment returns from target date funds). Second, OregonSaves allows workers to contribute to the same account via different employers. In other words, workers can accumulate retirement savings in the same account over time. This feature of account-specific contributions can potentially encourage employees to accumulate more personal savings, especially for those working in smaller firms with high job turnover rates.

OregonSaves was rolled out to private-sector workers lacking access to workplace retirement plans in seven waves. A first wave of firms volunteered to be in the pilot program, followed by six compulsory waves. Employer waves were determined by the number of employees at the firm, with larger employers having to register earlier than smaller firms. For example, the largest firms (100+ employees) began a compulsory registration period on October 1, 2017, and the smallest firms (4 or fewer employees) will start enrolling May 12, 2020. In practice, however, some smaller firms did register earlier than required, and some unknown number of larger firms may not have registered to date. As of June 29, 2019, OregonSaves was still rolling out to smaller employers. It has been announced that an employer penalty will be levied on companies that do not provide access to their own retirement plans or to OregonSaves for employees, but the date for implementation of the fines has been pushed back.

Once an employer is registered, the firm submits employees' Social Security numbers, dates of birth, and names to OregonSaves, after which a 30-day enrollment period begins. During the enrollment period, employees may opt out of the program. If they do not do so during the first 15 days, OregonSaves then conducts an identity verification check. Employees who are successfully identified are then deemed eligible for enrollment at the end of the 30-day window.

2.2 Data and Descriptive Statistics

Using individual-level administrative data from the first two years of the OregonSaves program, I present empirical evidence on (a) the impact of OregonSaves on expanding access to workplace retirement savings programs, (b) the characteristics of employers providing access to OregonSaves for their employees, (c) the characteristics of workers covered by OregonSaves, (d) the impact of OregonSaves on retirement savings, and (e) early evidence on the effect of automatic escalation in savings rates on participation and contributions.[2]

2.2.1 OregonSaves Expansion and Characteristics of Registered Employers

As of June 29, 2019, 4,970 employers had registered their businesses in OregonSaves. This means that they previously did not offer employer-sponsored retirement plans, and all current and future employees would have access to OregonSaves with an option to opt out. About 171,243 individuals had information provided to OregonSaves by an employer, and median firm size was 16. Employees' average age in 2019 was 37. As of June 29, 2019, OregonSaves had accumulated $22.7 million in total assets.

Food services and retail trade are two of the largest industries represented in OregonSaves in terms of the number of registered employers. Food services and health care are two of the largest industries in terms of the number of employees ever had access to OregonSaves.

[2]Additional descriptive results are documented in Chalmers et al. (2019).

It is our understanding that the large number of workers in health care can best described as home-health care workers. Finance, insurance, and management firms are some of the smallest industries in OregonSaves, in terms of both the number of registered employers and employees.

2.2.2 Characteristics of Workers Having Access to OregonSaves and Their Participation and Contribution Decisions

Panel A of Table 2 itemizes the status of the 171,243 employees who had a chance to enroll in OregonSaves. During the enrollment window, 41,757 (24.4%) employees opted out, while another 21,600 (12.6%) employees opted out after the enrollment window. There were 29,332 (17.1%) employees awaiting the background check, which, in many cases, extends their pending status. There were 12,630 (7.4%) employees who enrolled and passed their background checks, but their employers had not yet submitted payroll. Finally, 65,924 (38.5%) names were enrolled, where the background check was successfully completed, the employer was submitting deferrals for at least one employee, and the employee had not opted out. In a sense, these are the employees who may now participate in OregonSaves. Nevertheless, the 29,332 pending cases and the 12,630 employees still to contribute are also potential participants for whom I cannot yet observe their choices. Of the original 171,243 names submitted, approximately 37% elected to opt out; this does not, however, imply that the complement of this group represents participants.

In principle, the program participation rate refers to the employees who are making or have made contributions to OregonSaves, as a percent of employees eligible to participate, working, and who have an employer cooperating with OregonSaves. Yet when measuring the participation rate, there are two challenges to defining the denominator. Given the data to which I have access, I cannot distinguish between someone who is working and not contributing, from someone who is not working. It is also difficult to identify employees not participating because of actions taken by their employers, rather than actions they themselves took. As result, I must define a group of potential participants which is eligible and active using a set of imperfect but necessary assumptions.

Panel B of Table 2 describes the group I term Eligible Active Workers (EAW): these are employees eligible for an OregonSaves account and who appear to be actively working for at least one employer making payroll contributions for at least one employee. To be more precise, the EAW group includes those who opted out of OregonSaves while still actively working, plus people with a positive account balance in the past but currently a zero balance, plus people with a positive account balance currently, plus people with a positive balance and positive current contribution. This group comprises 76,438 people. In this group, 23,503 individuals received a monthly contribution to their accounts in June 2019, with a mean contribution amount of \$110. For employees with a positive contribution amount and a positive savings rate, I estimate their monthly incomes (=contribution/contribution rate) to be \$2,182. By way of comparison, the March 2018 Current Population Survey reports average monthly income of \$4,843 (and median income of \$3,411) for individuals who worked in the previous year. This comparison supports the conclusion that OregonSaves serves a population with low- and mid- income levels.

Panel A of Table 3 presents data for the 40,652 OregonSaves participants having a positive OregonSaves account balance. Given total assets of \$22.7 million, the average balance per account stood at \$558 as of June 2019. Panel B of Table 3 shows that 28,083 of the 40,652 with a positive balance are classified as eligible active workers. When averaged over accounts with a positive balance, the average account balance for EAW is \$653.20.

To illustrate some of the challenges in defining participation rates, I refer to Table 3 where 40,652 individuals have a positive account balance. Some of these, however, are not defined as active. One might argue that the participation rate could include all people who have participated as a fraction of current EAW or 53% (40,652/76,438), which is the ratio of anyone with a positive balance relative to the EAW group. If I focus on EAW workers who are eligible for contributions and actively working, the participation rate includes EAWs who ever had a positive balance relative to all EAWs, or 41.3% (31,573/76,438). In June 2019, there were 23,503 people contributing to the program. If one were interested in the number of contributing employees in June 2019 as a fraction of EAW, this would produce a contribution participation rate of 30.7% (23,503/76,438). Benchmarking the numbers of participants is difficult relative to prior studies, because our data include multiple employers, multiple jobs for some employees, and months in which no contributions are paid, along with our limited ability to discern workers' employment status from our data especially when people opted out or set their savings rates to zero.

Table 4 presents the distribution of savings rates for eligible active workers (EAW). About 22.1% of the EAW elected the default rate of 5% in June 2019. About 4,000 or 5.3% of EAW had savings rates of 6%, a large fraction of which may be attributed to the auto-escalation feature of the plan. Details and evidence about auto-escalation are shown in Table 6 which will be discussed in the following section. Of the 76,438 EAW, 69% had savings rates of zero, a tally that includes people who opted out (closed their accounts), along with EAWs who later set their rates to zero without closing their accounts, to leave open the possibility of saving later. Of the remaining employees, few had savings rates other than 0, 5%, and 6%.

Table 5 offers a summary of the reasons people offered for opting out of the OregonSaves program. Panel A tallies answers provided by users where they had to select one of a set of choices: the most common reason given was that people felt they could not afford to save as 29% of those who opted out offered that explanation. Another 20.6% of those opting out said that they already had their own retirement plans, and 25% gave "other" reasons. Additionally, 8% suggested they were not interested in contributing through their current employers. Panel B offers additional insights into the more than 5,000 responses given when an employee elected the "other" category indicated in Panel A. The three most prominent rationales for opting out include that fact that people were no longer employed, were not interested, and were already near or in retirement.[3]

2.2.3 Automatic Escalation

Table 6 reports the impact of automatic escalation on participating and contribution decisions. On January 1, 2019, workers who had open accounts for six months were eligible for auto-escalation. Additionally, workers who initially elected any non-zero savings rates (default or non-default) were eligible for auto-escalation. Similar to the initial default savings rate, eligibles could actively opt out of the auto-escalation arrangement; if they did not, savings rates automatically increased on January 1 by 1 percent, and would continue to do so until they reached 10%. Panel A shows subgroups of all individuals eligible for auto-escalation. Panel B shows how eligible active workers (EAW) who were eligible for auto-escalation responded. Panel B is more informative because EAWs are active workers with positive earnings who make non-zero contributions. Individuals counted in Panel A include inactive workers not making positive contributions even with a non-zero savings rate recorded. Results for EAW are similar to the full sample in Panel A except for two numbers. First, only 10.7% of EAW opted out of the program after auto-escalation took into effect. This suggests that most individuals opted out of the program after auto-escalation, because they no longer worked for the employer offering OregonSaves. Second, 66.4% of EAW eligible for auto-escalation adhered to the new rates at the end of June, 2019, higher than 51.1% for all individuals.

In summary, our early findings for the first two years of OregonSaves suggest several preliminary conclusions. First, 4,970 employers complied with the mandate to register their businesses in OregonSaves as of June 29, 2019, most of which were small businesses with fewer

[3]Other themes included opposition to the government and to auto-enrollment plans, as well as anti-social comments such as "none of your dam business." Example comments are provided as-is with the exception that curse words have been slightly disguised.

than 20 employees. The largest industries represented in OregonSaves were food services and health care (mostly home health care workers). Second, through these registered employers, OregonSaves provided 171,243 private sector workers access to workplace retirement saving plans. Moreover, among these covered workers, 76,438 were eligible to contribute and were actively working so that they could make positive contributions to their OregonSaves accounts if they elected a positive savings rate. Of these, 41.3% participated in the program and 30.7% made a positive contribution in June 2019. The leading rationales for opting out were being unable to afford to save or having an existing retirement plan. About 72% of participating EAWs accepted the 5% default rate. The average monthly positive contributions were $110. Finally, when the savings rates automatically increased by 1 percent on January 1, 2019, about 70% of EAWs eligible for automatic escalation accepted the rate increase.

3 A Sufficient Statistic Framework for the Optimal Default Savings Rate

Optimally designing the default savings rate is one of the key policy considerations for state and municipal governments interested in launching a government-sponsored retirement savings program similar to OregonSaves. In this section, I develop a sufficient statistics framework to derive the optimal default rate depending on statistics that can be directly estimated from the OregonSaves data described in the previous section.

3.1 Setup

In a two-period intertemporal choice model, workers need to divide their labor income Z between consumption and savings for retirement. Each worker has a underlying preferred savings rate, denoted θ. The preferred savings rate is determined by three exogenous parameters, her income Z, her normative time preference δ, and her behavioral time preference γ. The normative time preference δ captures the normative reasons to discount future utility (e.g. non-labor wealth, family structure, health, or bequest motive). The behavioral time preference λ captures the behavioral reasons to underestimate future utility (e.g. time inconsistency or misinformation). Appendix A presents details about the microfoundation of the preferred saving rate θ. Workers with the same preferred saving rate are defined as the same type, $\theta := (Z, \delta, \gamma) \in \Theta$, where the density of each type is $m(\theta)$.

A policymaker launches an automatic enrollment retirement savings program with a default saving rate $r \in (0, 1]$. The default saving amount for a given type-θ of workers with earnings $Z(\theta)$ is $R(\theta) = r \cdot Z(\theta)$. Each type of workers chooses a pension saving amount $P(\theta)$ from two discrete options: the default saving amount $R(\theta)$ or the preferred saving amount $S(\theta)$. The preferred saving amount equals the preferred savings rate θ times their income: $S(\theta) = \theta \cdot Z(\theta)$. Workers allocate their income between consumption C and savings P. The indirect decision utility function for a type-θ worker in the presence of a default rate r is expressed as:

$$U(C(\theta), P(\theta); \theta, r, K) = u(C(\theta)) + \gamma(\theta)\delta(\theta)v(P(\theta)) - K \cdot \mathbf{1}\{P(\theta) = S(\theta)\}, \quad (1)$$

where $C(\theta) + P(\theta) = Z(\theta)$ and $P(\theta) \in \{S(\theta), R(\theta)\}$. The functions $u(\cdot)$ and $v(\cdot)$ are both increasing and concave. The disutility K in the presence of a non-zero default rate represents the perceived costs of actively opting out of the default choice. I will refer to K as the opt-out costs,[4] which include but are not limited to time and psychological costs of switching from the default rate to the worker's preferred rate. I assume that the preferred saving rate θ, which determines each worker's type, is independent of the default rate r.

The policymaker thinks workers should maximize normative utility N, which can differ

[4]The opt-out costs K specifically mean the costs of opting out of the default option, not opting out of the savings program. Opting out of the program is considered as electing a zero saving rate.

from decision utility U. The indirect normative utility function N is formally expressed as:

$$
\begin{aligned}
N(C(\theta), P(\theta); \theta, r, K, \pi) &= u(C(\theta)) + \delta(\theta)v(P(\theta)) - \pi K \mathbf{1}\{P(\theta) = S(\theta)\} \\
&= U + (1-\gamma(\theta))\delta(\theta)v(P(\theta)) + (1-\pi)K\mathbf{1}\{P(\theta) = S(\theta)\}, \qquad (2)
\end{aligned}
$$

subject to the same budget constraint $C(\theta) + P(\theta) = Z(\theta)$. Following Goldin and Reck (2018), I define πK as the fraction of the normative opt-out costs: that is the realized cost after workers take action to opt out of the default that reduces their welfare by πK. The remaining fraction $(1-\pi)K$ is the psychological opt-out costs that opted-out workers perceive ex ante but do not affect their welfare ex post. Similar to K, π is assumed to be homogeneous across the population.

Equation (2) presents two sources of discrepancy between U and N. First, from the policymaker's perspective, workers might undervalue the utility of savings. The size of the underestimation, $(1-\gamma(\theta))\delta(\theta)v(P(\theta))$, is defined as the *welfare internality of savings*. This is the welfare gain of savings that workers do not consider when making saving decisions. One potential cause of this underestimation is due to the difference in time preferences between workers and the policymaker. Specifically, the policymaker is more forward-looking and discounts the value of future utility less than workers. This hypothesis is related to a large body of literature examining the disagreement in time preferences between the long-run self and the short-run self, where a policymaker can act like the long-run self (Laibson, 1997; O'Donoghue and Rabin, 1999). Moser and Olea de Souza e Silva (2017) and Choukhmane (2018) analyze the welfare consequences of time inconsistency in the context of retirement saving policies. A paper by Ericson and Laibson (2018) uses the term "present-focused" preferences to characterize individuals overestimating immediate utility compared to future utility documented in models such as hyperbolic and quasi-hyperbolic discounting, procrastination, and naivetè. Another potential reason for the underestimation of the utility of savings could be misinformation: that is, the policymaker may have more accurate information than do workers regarding public sources of retirement income such as Social Security and means-tested social transfers. Based on ambiguous or incorrect information, workers could be too optimistic about retirement support from social insurance and undervalue the importance of accumulating personal savings.

A second source of discrepancy between decision utility U and normative utility N could be that workers overlook the benefit from making an active decision.The size of the benefit from taking action, $(1-\pi)K$, is defined as the *welfare internality of action*. This is the welfare gain of taking action because workers perceive the cost before opting out of the default but the cost does not exist after opting out. One potential cause is that workers overestimate opt-out costs. Such a miscalculation could explain why people stay at the default even though it may not be their preferred choice (Bernheim et al., 2015; Goldin and Reck, 2018; Luco, 2019). Underestimation of the benefit from making an active decision could also be caused by inattention (Caplin and Dean, 2015; Karlan et al., 2016; Gabaix, 2019). In the context of retirement savings, workers may fail to pay attention to planning for retirement or notice any policy changes that could impact their retirement security, so that they remain at the default.

Given worker's type-specific choices of consumption $C(\theta)$ and savings $P(\theta) \in \{S(\theta), R(\theta)\}$, the policymaker will select a default rate r to maximize aggregate normative utility weighted by type-specific Pareto weights $\alpha(\theta)$:

$$W(r) = \max_{r} \int_{\Theta} \alpha(\theta) N(C(\theta), P(\theta); \theta, r, K, \pi) dm(\theta) \tag{3}$$

subject to individual optimization

$$\{C(\theta), P(\theta)\} = \arg\max_{\{C,P\}} U(C, P; \theta, r, K) \tag{4}$$

where

$$C + P = Z(\theta) \text{ for all } \theta.$$

3.2 Optimal default savings rate

Let r^* denote the optimal default savings rate. Next I consider the welfare effect of a marginal increase in the optimal default rate from r^* to $r^* + dr$. Based on the individual optimization problem characterized in Equation (4), workers of the same type select the same contribution amount $P(\theta) \in \{S(\theta), R(\theta)\}$. For a continuum of types $\theta \in [0, 1]$, workers whose preferred saving rates are between θ_l and θ_h will adhere to the default saving rate where $\theta_l < d < \theta_h$. The density of workers saving at the default $m_r = m_l + m_h = \int_{\theta=\theta_l}^{d} dm(\theta) + \int_{\theta=d}^{\theta_h} dm(\theta)$. I define workers who remain at the default as passive savers, where m_l is the fraction of passive savers (in the population) whose preferred rates are below the default, and m_h is the fraction of passive savers whose preferred rates are above the default. I refer to m_l as l-type passive savers, and m_h as h-type passive savers. Figure 1 displays how each type of passive savers responds to a marginal perturbation of the optimal default rate.

To derive a formula for the optimal default rate that is empirically implementable from the theoretical welfare framework, I introduce the following sufficient statistics:

- ϵ_l: the (observed) semi-elasticity of the percentage change in the density of l-type passive savers with preferred rates below the default (dm_l) with respect to all passive savers ($m_r = m_l + m_h$), as the default rate increases by 1 percentage point (dr), equal to $\dfrac{dm_l}{m_r}\dfrac{1}{dr}$;
- ϵ_h: the (observed) semi-elasticity of the percentage change in the density of h-type passive savers with preferred rates above the default (dm_h) with respect to all passive

savers ($m_r = m_l + m_h$), as the default rate increases by 1 percentage point (dr), equal to $\frac{dm_h}{m_r}\frac{1}{dr}$;

- $g(\theta)$: type-specific social marginal welfare weights. This indicates the social marginal value of savings for a given type-s worker relative to the marginal value of public funds (λ) evaluated at the optimal default rate in units of dollars. The social marginal welfare weight measures the social value of each dollar that a type-θ worker saves from the policymaker's perspective. Specifically, the policymaker values an additional dollar of savings from a type-θ worker as much as \$$g(\theta)$ from public funds. The welfare weights can be formally expressed as:

$$g(\theta) := \frac{\alpha(\theta)v'_{R^*(\theta)}}{\lambda}. \tag{5}$$

  The derivative $v'_{R^*(\theta)} := \frac{dv(R^*(\theta))}{dR^*(\theta)}$, where $R^*(\theta) = r^*Z(\theta)$, r^* is the optimal default rate, and $Z(\theta)$ is the labor income for type-θ workers.

The welfare analysis is also based on several key assumptions sufficient to derive the optimal default rate:

1. Individuals make their saving decisions once at the beginning of their working lives.[5]

2. The total opt-out costs K and the fraction of the normative opt-out costs π are homogeneous across types.

3. Individual preferred rates s are independent of the default rate r.

4. The utility function of savings $P(\theta)$ is linear: $v(P(\theta)) = P(\theta)$.

[5] Most retirement saving plans allow people to adjust their savings rates anytime, although in reality few people do so. Usually plan participants do not make active adjustments after they make their initial saving decisions (accepting the default, switching to a non-default rate, or opting out of the program) unless they face some exogenous shocks (i.e., income or unemployment shocks).

Next I characterize the optimal default rate r^* based on the policymaker's problem described in Equations (3) - (4). A marginal increase in r^* does not impact active savers because they have opted out of the default before the marginal increase. As previously defined, active savers are those whose preferred rates are below θ_l or above θ_h.

A marginal increase in r^* affects passive savers who accept the default before the marginal increase. Their preferred rates are between θ_l and θ_h. The welfare effect on passive savers can be decomposed into three components, which are visualized in Figure 1. The first component, which is expressed as the first term in Equation (6), represents the mechanical increase in savings for passive savers as the default rate that they adhere to marginally increases. For a type-θ passive saver, the increase in savings changes her normative utility by $\frac{dN(R^*(\theta))}{dr}$.[6]

The second component of the welfare effect is the increase in h-type passive savers. H-type passive savers, denoted m_h, are individuals with a preferred rate above the optimal default r^* and choosing to stay at the default because their preferred rate is close to the default. When the default rate is r^*, some h-type individuals become active savers by opting out of the default rate. When the default rate marginally increases to $r^* + dr$, h-type individuals on the margin between opting out and adhering to the default choose to stay at the default because the new default rate $r^* + dr$ is closer to their preferred rate than r^*. The increase in the fraction of h-type passive savers is expressed as $\frac{dm_h}{dr}$ in the second term of Equation (6). Additionally, h-type individuals on the margin change their savings level. When they are active savers under r^*, they save at their preferred amount: $S_h = s_h Z_h$. When they are passive savers under $r^* + dr$, they save at the default amount: $R_h = (r^* + dr)Z_h$. Consequently, the normative utility changes from $N(R_h)$ to $N(S_h)$ as the default rate marginally increases.

The third component of the welfare effect is the decrease in l-type passive savers. L-type

[6] I use $N(R^*(\theta))$ to represent $N(C(\theta), R^*(\theta); \theta, r, K, \pi)$ in Equation (3) subject to the budget constraint $C(\theta) + R^*(\theta) = Z(\theta)$, where $R^*(\theta) = r^* \cdot Z(\theta)$, r^* is the optimal default rate, and $Z(\theta)$ is the labor income.

passive savers, denoted m_l, are individuals with a preferred rate below the optimal default r^* and choosing to stay at the default. When the default rate is r^*, some l-type individuals are passive savers by accepting the default rate. When the default rate marginally increases to $r^* + dr$, l-type individuals on the margin choose to opt out of the default because the new default rate $r^* + dr$ is farther from their preferred rate than r^*. The decrease in the fraction of l-type passive savers is expressed as $\frac{dm_l}{dr}$ in the third term of Equation (6). L-type individuals on the margin also change their savings level. When they are passive savers under r^*, they save at their default amount: $R_l = r^* Z_l$. When they are active savers under $r^* + dr$, they save at their preferred amount: $S_l = s_l Z_l$. Therefore, the normative utility changes from $N(S_l)$ to $N(R_l)$ as the default rate marginally increases. The first-order condition for the social welfare function W in Equation (3) equals zero at the optimum:[7]

$$\begin{aligned} \frac{dW(r^*)}{dr} &= \frac{d}{dr}\int_{\theta=\theta_l}^{\theta_h} \alpha(\theta) N(P(\theta)) dm(\theta) \\ &\approx \int_{\theta=\theta_l}^{\theta_h} \alpha(\theta) \frac{dN(R^*(\theta))}{dr} dm(\theta) + \frac{dm_h}{dr}\alpha_h(N(R_h) - N(S_h)) - \frac{dm_l}{dr}\alpha_l(N(S_l) - N(R_l)) \\ &= 0. \end{aligned} \tag{6}$$

Proposition 1. *Based on Assumptions 1-4, the default savings rate satisfies the following equation at the optimum:*

$$r^* = \frac{dI + dS_l - dS_h + dK_l - dK_h}{dR_l - dR_h}.$$

Proof. See Appendix B. The overall welfare effect can be decomposed into several terms

[7] The objective function $N(P(\theta))$ is an abbreviation for $N(C(\theta), P(\theta); \theta, r, K, \pi)$ in Equation (3) subject to the budget constraint $C(\theta) + P(\theta) = Z(\theta)$. Retirement savings $P(\theta)$ is chosen between the default saving amount at the optimal default rate $R^*(\theta)(= r^* Z(\theta))$ and the preferred saving amount $S(\theta)(= \theta Z(\theta))$. The differentiation under the integral sign employs the Leibniz integral rule where the end points of the interval of the integral θ_l and θ_h are functions of the derivative argument r.

after the optimal default rate marginally increases from r^* to $r^* + dr$:

1. The aggregate weighted social welfare gain to all passive savers on the intensive margin dI: As the default rate increases marginally increases, l-type passive savers on the intensive margin increases their savings by $dr \cdot Z_l$. Although they might feel indifferent to the marginal policy change, there is an increase in the welfare internality of savings, which is the realized welfare gain to passive savers that they do not internalize. Based on Equation (1), the marginal increase in the welfare internality of savings for a l-type worker is $(1-\gamma_l)\delta_l dr Z$, and the marginal increase is weighted by g_l in terms of its impact on social welfare. The social welfare gain on the intensive margin is then weighted by the fraction of l-type passive savers $\frac{m_l}{m_r} \cdot g_l \cdot (1-\gamma_l)\delta_l dr Z_l$. Analogously, the social welfare gain to h-type passive savers is $\frac{m_h}{m_r} \cdot g_h \cdot (1-\gamma_h)\delta_h dr Z_h$. The aggregate weighted social welfare gain on the intensive margin is: $dI = \frac{m_l}{m_r} \cdot g_l \cdot (1-\gamma_l)\delta_l dr Z_l + \frac{m_h}{m_r} \cdot g_h \cdot (1-\gamma_h)\delta_h dr Z_h$.

   The optimal default r^* increases with dI. This suggests that, if passive savers benefit from saving at the default level, *raising* the default savings rate improves social welfare.

2. The welfare gain to l-type workers for switching to their preferred rate s_l under the new default $r^* + dr$, denoted dS_l: As the new default rate is farther from their preferred rate, the fraction of the l-type workers on the margin of opting out of the default is: $\frac{dm_l}{m_r} = dr|\epsilon_l|$.[8] Each l-type worker opting out of the default obtains the welfare internality of saving at their preferred rate $(1-\gamma_l)\delta_l\theta_l Z_l$ weighted by g_l. The total social welfare gain is: $dS_l = dr|\epsilon_l| \cdot g_l \cdot (1-\gamma_l)\delta_l\theta_l Z_l$.

   The optimal default r^* increases with dS_l. If l-type workers benefit from saving at their preferred rate, the policymaker should further *raise* the default rate and encourage l-type workers to make an active decision and elect their preferred rates.

3. The social welfare loss to l-type workers for opting out of the default rate, denoted dR_l:

[8] By the definition of ϵ_l in Section 3.2, $\epsilon_l = \frac{dm_l}{m_r}\frac{1}{dr}$.

As l-type workers on the margin ($dr|\epsilon_l|$) stop saving at the default, the social welfare loss equals the welfare internality of saving at the default $(1-\gamma_l)\delta_l r^* Z_l$ weighted by its social marginal weight g_l. The total social welfare loss to l-type workers on the margin for no longer saving at the default is: $dR_l \cdot r^* = dr|\epsilon_l| \cdot g_l \cdot (1-\gamma_l)\delta_l r^* Z_l$.

The optimal default r^* decreases with dR_l. If l-type workers generate large welfare loss by opting out of the default, the policymaker should *lower* the default to keep them from opting out.

4. The social welfare loss to h-type workers for no longer saving at their preferred rate s_h, denoted dS_h: As the new default moves closer to h-type workers' preference, the fraction of h-type workers on the margin of starting to save at the default ($\frac{dm_h}{m_r} = dr|\epsilon_h|$)[9] no longer have the welfare internality of saving at their preferred rate, $(1-\gamma_h)\delta_h\theta_h Z_h$, weighted by g_h. The welfare loss to h-type workers for no longer saving at their preference is: $dS_h = dr|\epsilon_h| \cdot g_h \cdot (1-\gamma_h)\delta_h\theta_h Z_h$.

   The optimal default r^* decreases with dS_h. If h-type workers significantly benefit from saving at their preferred rate, the policymaker should *lower* the default rate so that h-type workers do not accept the default as it is far from their preference.

5. The social welfare gain to h-type workers for starting to save at the default rate dR_h: As h-type workers on the margin ($dr|\epsilon_h|$) start saving at the default, the social welfare gain for each l-type worker equals the welfare internality of saving at the default $(1-\gamma_h)\delta_h r^* Z_h$ weighted by g_h. The total social welfare gain to l-type workers on the margin for starting to save at the default is: $dR_h \cdot r^* = dr|\epsilon_h| \cdot g_h \cdot (1-\gamma_h)\delta_h r^* Z_h$.

   The optimal default r^* increases with dR_h. If h-type workers benefit from saving at the default rate, then the policymaker should *raise* the default to encourage them to save at the default.

[9] By the definition of ϵ_h in Section 3.2, $\epsilon_h = \frac{dm_h}{m_r}\frac{1}{d_r}$.

6. The social welfare gain to l-type workers for making an active choice dK_l: For each l-type worker on the margin of electing their preferred rate, they obtain the positive welfare internality of action measured by $(1-\pi)K$. It could be interpreted as the positive welfare gain for overcoming inertia and making an active savings decision. The welfare internality of action has social consequences because the marginal personal welfare gain can improve social welfare by g_l. The social welfare gain to all l-type workers on the margin $(dr|\epsilon_l|)$ for taking action is: $dK_l = dr|\epsilon_l| \cdot g_l \cdot (1-\pi)K$.

   The optimal default r^* increases with dK_l. If l-type workers benefit from making an active choice, the policymaker should *raise* the default to encourage them to opt out of the default.

7. The social welfare loss to h-type workers for no longer making an active choice is $\frac{dK_h}{dr} = |\epsilon_h| g_h (1-\pi)K$. For each h-type worker on the margin of accepting the default, they become inactive and lose the welfare internality of action, $(1-\pi)K$, weighted by g_h. The social welfare loss to all h-type workers on the margin of no longer taking action is: $dK_h = dr|\epsilon_h| \cdot g_h \cdot (1-\pi)K$.

   The optimal default r^* decreases with dK_h. If h-type workers significantly benefit from making an active choice, the policymaker should *lower* the default so that they have incentives to opt out of the default that is far from their preferred rate.

4 Estimating Key Parameters for the Optimal Default Savings Rate

In this section, I outline an empirical strategy to identify key statistics to calculate the optimal default savings rate in Proposition 3.2 using OregonSaves data described in Section

2. Table 11 lists all the statistics that need to be estimated and their values. Key statistics discussed in this section are:

- ϵ_l: the (observed) semi-elasticity of the percentage change in the fraction of l-type passive savers (with preferred rates below the default, denoted by dm_l) with respect to the default rate
- ϵ_h: the (observed) semi-elasticity of the percentage change in the fraction of h-type passive savers (with preferred rates above the default, denoted by dm_h) with respect to the default rate;
- δ_l, δ_h: the normative time preference for l- and h-type passive savers; and
- γ_l, γ_h: the behavioral time preference for l- and h-type passive savers;

4.1 Semi-elasticities ϵ_l and ϵ_h

The (observed) semi-elasticity ϵ_l measures the percentage change in the fraction of l-type passive savers with preferred rates below the default (dm_l) with respect to all passive savers ($m_r = m_l + m_h$), as the default rate increases by one percentage point (dr), equal to $\frac{dm_l}{m_r}\frac{1}{dr}$. Similarly, ϵ_h is the (observed) semi-elasticity of the percentage change in the density of h-type passive savers with preferred rates above the default (dm_h) with respect to all passive savers ($m_r = m_l + m_h$), as the default rate increases by one percentage point (dr), equal to $\frac{dm_h}{m_r}\frac{1}{dr}$. Suppose the default rate increased from r to r', then ϵ_l and ϵ_h can be formally expressed as:

$$\begin{aligned}\epsilon_l(r) &= \frac{dm_l}{m_r}\frac{1}{dr} \\ &= \frac{m_{l'} - m_l}{m_r}\frac{1}{r' - r}, \end{aligned} \tag{7}$$

and

$$\begin{aligned}\epsilon_h(r) &= \frac{dm_h}{m_r}\frac{1}{dr} \\ &= \frac{m_{h'} - m_h}{m_r}\frac{1}{r' - r},\end{aligned} \tag{8}$$

where m_l' is the fraction of l-type passive savers under the new default rate r', m_l is the fraction of l-type passive savers under the original default rate r, $m_r = m_l + m_h$ is the total fraction of passive savers, m_h' is the fraction of h-type passive savers under the new default rate r', and m_h is the fraction of h-type passive savers under the original default rate r. when the default rate is d' and m_r is the fraction of passive savers when the default rate is d.

Based on Equations (7) and (8), two strategies are available to estimate ϵ_l and ϵ_h with distinct advantages. A key assumption these two strategies rely on is that the semi-elasticities are constant across default rates: $\epsilon_l(r) = \epsilon_l$ and $\epsilon_h(r) = \epsilon_h$. [10]

4.1.1 Identification from Automatic Escalation in OregonSaves

I exploit the exogenous variation in the default rate resulting from automatic escalation to identify the (observed) semi-elasticity for l-type passive savers ϵ_l. I use workers' responses to auto-escalation to proxy how they would respond differently to two initial default rates. Section 2 and Table 6 describe the institutional details and summary statistics of automatic escalation.

I start by identifying $m_{l'} - m_l$ in Equation (7), which is the change in the fraction of l-type passive savers when the default rate automatically increased from 5% to 6%. Although I do not directly observe the fraction of l-type passive savers with an underlying preferred rate below the default rate, I can infer the change in the fraction of l-type passive savers from

[10] This empirical assumption can be relaxed when I observe long-term data from OregonSaves.

how many of them become active savers after auto-escalation. The increase in the fraction of l-type active savers is the same size as the decrease in the fraction of l-type passive savers, based on the theoretical assumption 3 in Section 3.2 that the underlying preferred rate is invariant.

Table 7 presents the distribution of savings rates for eligible active workers (EAW) eligible for auto-escalation at the end of November 2018 and at the end of June 2019. I exclude EAW eligible for auto-escalation who opted out of the auto-escalation arrangement before it took effect on January 1, 2019. Panel B of Table 6 shows that, among 5,694 eligible EAW, 1,186 ($= 410 + 776$) opted out of auto-escalation before it took effect. This leaves the sample for estimating the elasticity ϵ of 4,508 (= 5,694 - 1,186). The reason I exclude these is that I need a precise estimate of individual responses *after* the exogenous rate increase. The 1,186 eligible EAW who opt out of auto-escalation in advance were done so for various other reasons. November 2018 is the last month before individuals received notifications about auto-escalation that would take into effect on January 1, 2019. June 2019 is six months after auto-escalation occurred, so that eligible workers could have had enough time to adjust their savings rates in response to the rate increase.

Table 7 shows that 6.6% are l-type active savers saving between 1% - 4% under the 5% original default rate before auto-escalation, and 17.2% are l-type active savers between 1% - 5% under the 6% new default rate after auto-escalation. As a result, l-type active savers increase by 10.6% after auto-escalation. This suggests that l-type passive savers decreases by 10.6% after auto-escalation: $m_{l'} - m_l = -10.6\%$. I also observe that there are 91.9% of passive savers under the 5% default rate: $m_r = 91.9\%$ in Equation (7). It is worth noting that in the November distribution, no eligible EAW opted out of the program because workers had to participate in OregonSaves to be eligible for auto-escalation. Additionally, their accounts had to be open for at least 6 months to be eligible (before June 30, 2018). As the OregonSaves program is still rolling out and most workers were registered after June 30, 2018, only a small fraction of EAW were eligible for auto-escalation. I will be able to observe more workers eligible for auto-escalation in the future. I plug in the numbers into Equation (7) and get:

$$\begin{aligned}\epsilon_l &= \frac{m_{l'} - m_l}{m_r} \cdot \frac{1}{r' - r} \\ &= \frac{-10.6\%}{91.9\%} \cdot \frac{1}{6-5} \\ &= -0.12. \end{aligned} \tag{9}$$

The estimate of ϵ_l suggests that 12% of l-type passive savers (whose preferred rates are below the default) stopped saving at the default rate when it increased by 1 percentage point. Although I can use auto-escalation to identify ϵ_l, I cannot identify ϵ_h, which quantifies the fraction of h-type active savers becoming passive savers as the initial default rate increases by 1 percentage point (h-type are savers with a preferred rate higher than the default). Since h-type active savers opted out of the original 5% default rate before auto-escalation, they were unaffected by the increase in the default rate. I do not know how they would respond to a default rate other than 5%.

4.1.2 Identification Using Data from Related Literature

I use data from Beshears et al. (2012) to estimate ϵ_h. That analysis studied differential responses to the default rate by income in three employer-sponsored retirement saving plans. They found that the low-paid were more likely to save at the default than the high-paid. Using their data, I investigate two groups of employees in the same firm who were assigned two different default rates. Firm C in their paper had a 3% default savings rate for 2,785 full-time employees hired at the firm between January 1, 2003 and February 29, 2004. The same firm C had a 5% default savings rate for 3,765 full-time employees hired between June 1, 2005 and July 31, 2006. Employers provided matching contributions in both time periods. The maximum employer match was 7%, meaning that employers matched employees' contributions up to 7% of their earnings if employees contributed 7% or more.

The key underlying assumption required to exploit the variation in default rates to estimate ϵ_h is that the characteristics of the two cohorts facing different default rates must be similar. This assumption largely holds based on the summary statistics provided by Beshears et al. (2012): the mean age for both groups was 33-34 years and the mean annual income was \$42,000 - \$44,000. Employees in Firm C on average earned more than eligible workers in OregonSaves whose average annual income is \$26,212.8 (in 2019 dollars) as shown in Table 2. Appendix C provides the distributions of employee savings rates at Firm C when the default rate was 3% and 5%. Based on Equation (8), I compute the change in the fraction of h-type passive savers ($m_{h'} - m_h$) with respect to the fraction of all passive savers (m_r). Similar to the calculation of ϵ_l in Section 4.1.1, the increase in the fraction of h-type passive savers is the same size as the decrease in the fraction of h-type active savers. Data from Beshears et al. (2012) show a decrease by 11% of h-type active savers when the default rate increased from 3% to 5%. That is equivalent to a 11% increase in h-type passive savers: $m_{h'} - m_h = 11\%$. I also observe 32% total passive savers under the 3% default rate: $m_r = 32\%$. Plugging these numbers into Equation (8), I get:

$$\begin{aligned}
\epsilon_h &= \frac{m_{h'} - m_h}{m_r} \cdot \frac{1}{r' - r} \\
&= \frac{11\%}{32\%} \cdot \frac{1}{5 - 3} \\
&= 0.17. \qquad (10)
\end{aligned}$$

The value of ϵ_h suggests that 17% of active savers would start saving at the default rate if the initial default rate increased by 1 percentage point. I can also use data from Beshears et al. (2012) to obtain an estimate for ϵ_l:

$$\begin{aligned}\epsilon_l' &= \frac{m_{l'} - m_l}{m_r} \cdot \frac{1}{r' - r} \\ &= \frac{-8\%}{32\%} \cdot \frac{1}{5-3} \\ &= -0.13. \end{aligned} \tag{11}$$

I find $\epsilon_l'(= -0.13)$ close to $\epsilon_l(= -0.12)$ estimated from the OregonSaves data in Section 4.1.1. One caveat of using any data from employer-sponsored retirement plans is that the estimates could be confounded by the employer matching cap. Specifically in firm C studied by Beshears et al. (2012), that firm offered matching up to 7%. As the default rate moveed closer to 7% (from 3% to 5%), employees were more likely to actively switch to 7% to take full advantage of the matching benefit than they would do without matching. Consequently, when the default rate is 5%, I expect more active savers with matching than without matching. Equivalently, I expect fewer passive savers with matching than without matching, which makes the observed $m_{h'}$ biased upwards and ultimately biases ϵ_h downwards in Equation (10).

4.2 Normative and Behavioral Time Preferences δ and λ

The time preference parameters in the optimal default rate formula in Proposition 3.2 captures how a normative and a present self would discount future utility differently due to reasons including present bias, inattention, and misinformation. This section illustrates one method to experimentally elicit present-biased discount rates.

4.2.1 Estimation Strategy Using Survey Data

Besides the individual-level administrative records of OregonSaves savings data, I surveyed a subgroup of OregonSaves eligible workers in June 2019, including those who opted out and who were participating. I sent the survey to 441 workers and 143 responded (32.4% response rate). Survey respondents had two weeks to answer the survey through an email link and all respondents received a $40 Starbucks gift card for completing the survey.

Our identification strategy, called the Convex Time Budget (CTB) approach, follows Andreoni and Sprenger (2012) to simultaneously estimate the time preferences $\lambda - \delta$ and the curvature of the utility function. Survey participants answered questions about how to allocate 100 experimental "tokens" to either a "sooner" time t, or a "later" time $t + k$, at different "token exchange rates" r. They choose C tokens to receive at a sooner time and R tokens to receive at a later time continuously along a convex budget set:

$$(1 + r)C + R = 100. \tag{12}$$

I used variations in starting times t to identify respondents' behavioral discount rates λ. I used variations in delay length k and interest rates $(1+r)$ to identify the normative discount rates δ and utility function curvature. Participants faced 16 intertemporal decisions involving 16 combinations of $(t, k, 1 + r)$, where $t = (0, 1)$, $k = (1, 2)$, and $1 + r = (1, 1.01, 1.02, 1.05)$. Table 8 shows the time periods, token budgets, token unit values, and annual interest rates for all 16 combinations. Appendix D provides the survey questions where four questions with the same set of (t, k) combination are displayed on the same page. Participants could change their answers to questions within the same set, but they could not change answers after they moved on to the next page with a different (t, k) combination.

For each question, participants had a budget of 100 tokens. Tokens allocated at a sooner time were worth a_t while tokens allocated to a later time were worth a_{t+k}. For example, in the first question, each token was worth \$100 today and \$100 in a year. Participants were asked to move a slider to divide the 100 tokens between two time points as they preferred. In this question, $t = 0$, $k = 1$, and $1 + r = \frac{a_{t+k}}{a_t} = 1$. If one allocated 60 tokens today and 40 tokens to a year away, the survey would show the total dollar amount she would have today, \$6,000 (= \$100 × 60), and the total dollar amount she would have in a year, \$4,000 (= \$100 × 40). The total dollar amount allocated to a sooner time was denoted by C and the total dollar amount allocated to a later time was denoted by R in Equation (12).

Given consumption at a sooner time C and consumption at a later time R, I express decision utility U as a multi-period time separable CRRA (constant relative risk aversion) utility function subject to budget constraint (12):

$$U(C, R) = \frac{1}{\alpha}(C - W)^{\alpha} + \lambda\delta^{k}\frac{1}{\alpha}(R - W)^{\alpha}.$$

The parameter α is the CRRA curvature parameter, λ is the behavioral time preference, δ is the normative time preference, and k is the delay length between the two time points. The variable W is background consumption which is the negative of the minimum consumption level in a typical year. Following Andreoni and Sprenger (2012), I assume that the background consumption level at two time points is the same. When I log-linearize the decision utility function $U(C, R)$, I obtain:

$$\ln\left(\frac{C - W}{R - W}\right) = \left(\frac{\ln\lambda}{\alpha - 1}\right)\mathbf{1}\{t = 0\} + \left(\frac{\ln\delta}{\alpha - 1}\right)k + \left(\frac{1}{\alpha - 1}\right)\ln(1 + r). \tag{13}$$

W is the negative of minimum annual consumption level asked in the survey. C and R are survey responses to the intertemporal allocation questions described in Appendix D; $\mathbf{1}\{t = 0\}$ is an indicator if the sooner time period is today; k is the delay length between the sooner time and the later time described in Table 8; and $\ln(1 + r)$ is the natural log of the annual interest rate in Table 8. I use a two-limit Tobit maximum likelihood regression to estimate parameters λ, δ, and α.

I also estimate these parameters using an alternative utility function, constant absolute risk aversion (CARA). The decision utility U in this formulation subject to budget constraint (12) is expressed as:

$$U(C, R) = -\exp(-\rho C) - \lambda\delta^k \exp(-\rho R),$$

where ρ is the coefficient of absolute risk aversion. The log-linearized utility function is:

$$C - R = \left(\frac{\ln \lambda}{-\rho}\right)\mathbf{1}\{t = 0\} + \left(\frac{\ln \delta}{-\rho}\right)k + \left(\frac{1}{-\rho}\right)\ln(1 + r). \tag{14}$$

4.2.2 Results

Table 9 shows estimates of λ and δ from two-limit Tobit maximum likelihood regressions. There were 143 survey respondents who answered the time preference survey questions, and they made 1,765 intertemporal choices in total. Column 1 shows estimates of the CRRA regression (Equation (13)). The annual background consumption $w = -1,040$, equal to the negative of the minimum consumption level among all survey respondents. The average normative discount factor δ is 0.995 (standard deviation 0.006), and the average behavioral discount factor is λ is 0.987 (s.d. 0.005). Column 2 shows estimates of the CARA regression (Equation (14)). The average δ is 0.987 (s.d. 0.005) and the average λ is 0.993 (s.d. 0.007). For a baseline calculation of the optimal default rate, I assume that the normative time preference is the same for l- and h-type passive savers: $\delta_l = \delta_h = 0.995$. The behavioral time preference for h-type passive savers is assumed to be the average level under CRRA utility: $\gamma_h = 0.987$. The behavioral time preference for l-type passive savers is assumed to be one standard deviation below the average: $\gamma_l = 0.982$.

5 Computing the Optimal Default Savings Rate

The optimal default rate is computed by plugging the values listed in Table 11 into Proposition 3.2. An additional empirical assumption required to calculate dI, the welfare impact on the intensive margin, is that I use an unweighted average welfare component to approximate a weighted average welfare component, as the weighting of different types of passive savers is unobserved. The optimal default rate r^* using baseline estimates can be computed as follows:

$$
\begin{aligned}
r^*\% &= \frac{dI + dS_l - dS_h + dK_l - dK_h}{dR_l - dR_h} \\
&= \frac{3120.1 + 2792.7 - 645.8 + 39.6 - 38.3}{698.2 - 71.8}\% \\
&= 8.4\%.
\end{aligned}
$$

The optimal default is higher than the current 5% default rate in OregonSaves mainly for two reasons. First, the fraction of passive savers accepting the optimal default rate could be overestimated. I use individual responses to auto-escalation to proxy how two identical groups of workers would respond to two initial default rates. Since the initial default rate is more salient than auto-escalation, passive savers are more likely to opt out of a high initial default rate compared to a low initial default than opting out of auto-escalation. Second, our estimates suggest that passive savers greatly benefit from saving at the default. The actual benefit of default savings could be lower than calculated because the current welfare framework does not take into account Social Security benefits. Additional retirement income from Social Security could diminish the marginal benefit of default savings. The combination of these two reasons implies that the actual social welfare gain from saving at the default could be lower than estimated. The 8.4% baseline calculation should therefore be considered as an upper bound of the optimal default rate.

5.1 Sensitivity Analysis

Table 12 reports estimates of the optimal default rate under alternative assumptions. I first consider alternative assumptions about individual time preferences. The second row of Table 12 reports that, if individuals with a low preferred savings rate are highly present-biased, the optimal default rate (8.2%) would be lower than the baseline value (8.4%). This is mostly because the policymaker wants to lower the default rate to attract present-biased individuals who would actively undersave from opting out the default. The third row shows the alternative optimal default rate if individuals with a low preferred savings rate do not highly value personal savings due to some normative reasons. These normative reasons could be a second retirement income source from social insurance programs or family members. The third row reports that the optimal default rate (8.5%) is slightly higher than the baseline value (8.4%) when normative reasons cause individuals to elect a low preferred savings rate. When the default rate is relatively high, opting out of the default rate and actively saving less is not necessarily welfare reducing for individuals with a second retirement income source. Moreover, a higher default rate could be welfare improving for passive savers who stay at the default rate.

The fourth row considers an alternative assumption about the (observed) semi-elasticity of the fraction of passive savers with respect to the default rate. The default rate remains the same (8.4%) when passive savers are less responsive to the default rate by opting out of the default rate. The fifth row reports the optimal default rate when the average cost of opting out of the default rate perceived by individuals is large. Recent studies such as Bernheim et al. (2015) find that the perceived opt-out cost could be in thousands of dollars. The fifth row suggests that the optimal default rate is stable around 8.4% despite a wide range for perceived opt-out costs.

6 Conclusion

This paper has proposed a tractable framework that directly connects empirical analysis of the causal impact of the default savings rate on individual saving behavior with welfare analysis of the optimal design of the default savings rate. I introduced a novel set of sufficient statistics to capture individual adherence to the default savings rate as the default rate varies. Given individual responsiveness to the default savings rate, I characterized how the level of the default savings rate impacts individual welfare. Specifically, the default savings rate could improve individual welfare by protecting workers from two types of behavioral biases: actively undersaving and inaction. In a unified welfare framework that incorporates these two biases, I showed that if workers tend to procrastinate to make an active decision, it might be welfare-improving to set the default rate at an undesirable level to compel individuals to opt out of the default rate and choose a non-default savings rate that maximizes their life cycle utility. In contrast, if the non-default preferred rate that individuals actively choose does not maximize their life cycle utility, it might be welfare-improving to set the default rate at a desirable level to encourage workers to stay at the default rate.

Using individual-level administrative and survey data from the first state-sponsored auto-enrollment plan in the U.S. called OregonSaves, I found that, when the default rate increased by one percentage point, about an additional 12% of workers who had passively stayed at the previous default rate switched to a non-default rate or opted out of the program. I also found that OregonSaves-eligible workers show little evidence of undervaluing the utility of savings. Given these estimates, a baseline calculation suggested that the optimal default savings rate should be set at 8%, somewhat higher than the current 5% default rate.

Analyzing optimal policy with reduced-form empirical identification has been widely adopted in the context of income transfer programs such as tax policy and social insurance. The present paper extends the applicability of this approach to default saving policy, and shows that the same approach to addressing welfare and optimal policy questions based on empirical evidence can be applied to a broader context of economic policies including income transfer programs and nudge policy.

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Table 1: State Legislation Establishing a State-Sponsored Retirement Plan, October 2019

State	Type of program	Status	Default rate	Program/Bill website
Oregon	Mandatory auto Roth IRA	Launched in July 2017	5%, auto escalation up to 10%	OregonSaves
Illinois	Mandatory auto Roth IRA	Launched in May 2018	5%, no auto escalation	Illinois Secure Choice
California	Mandatory auto Roth IRA	Launched in July 2019	5%, auto escalation up to 8%	CalSavers
Maryland	Mandatory auto Roth IRA	Scheduled to launch in mid-2020	To be determined	Maryland$aves
Connecticut	Mandatory auto Roth IRA	Bill passed in 2016	To be determined	Connecticut program
New Jersey	Mandatory auto Roth IRA	Bill passed in March 2019	3%	New Jersey Secure Choice Savings Program Act
Vermont	Voluntary to employers; auto Roth IRA to workers	Bill passed in June 2017	To be determined	Green Mountain Secure Retirement Plan
New York	Voluntary to employers; auto Roth IRA to workers	Bill passed in February 2018; scheduled to launch in April 2020	To be determined	New York State Secure Choice Savings Program Act
Washington	Expanding from a voluntary program to a mandatory program to all private-sector businesses	Voluntary program launched in 2015; bill for the mandatory program passed the State Senate in March 2019; waiting for a House floor vote	To be determined	Washington Secure Choice Savings Program Act
Massachusetts	Expanding from a voluntary program only to non-profits to a mandatory program to all private-sector businesses	Voluntary program launched in October 2017; bill for the mandatory program introduced in January 2019	To be determined	Massachusetts Secure Choice Savings Program Act

Note: In a mandatory auto Roth IRA program, private-sector employers are required to provide employees access to either a state-sponsored plan or an employer-sponsored plan such as 401(k). Employees are automatically enrolled in a retirement plan with a default contribution rate. They can always opt out or elect a non-default contribution rate. Roth IRA is an individual retirement account where contributions are not tax-free but qualified withdrawals and earnings in the account are tax-free. Besides these 10 states that have passed the legislation for a voluntary or a mandatory program, about another 21 states have introduced legislation but not yet enacted. AARP summarized the status of these 21 states: `https://www.aarp.org/ppi/state-retirement-plans/savings-plans/`.

Table 2: Summary Statistics for Individuals Ever Had Access to OregonSaves, June 2019

	N	%	$
Panel A: All individuals			
Total unique individuals entered by employers	171,243	100.0	–
Immediate opted-out individuals	41,747	24.4	–
Delayed opted-out individuals	21,600	12.6	–
Pending individuals	29,332	17.1	–
Enrolled individuals w/o payroll info	12,630	7.4	–
Enrolled individuals with payroll info	65,924	38.5	–
Panel B: Eligible active workers (EAW)			
Total EAW	76,438	100.00	–
Immediate opted-out workers	27,743	36.3	–
Delayed opted-out workers	17,122	22.4	–
EAWs with no balance	6,793	8.9	–
Suspended contributors	1,277	1.7	–
Contributors	23,503	30.7	–
Average monthly contributions if > 0, June 2019	–	–	110
Average monthly income	–	–	2,184

Note: Data from anonymized administrative records as of June 29, 2019. In Panel A, immediate opted-out individuals left the OregonSaves program during the first 30-day enrollment window. Delayed opted-out individuals left the OregonSaves program after the 30-day window. Pending individuals were in the background check, failed the background check, or in the 30-day window (all employers). Enrolled individuals with payroll information passed the background check and the initial 30-day window (at least 1 employer), but program is waiting for payroll information. Enrolled individuals with payroll information passed the background check, passed the initial 30-day window (at least 1 employer), and the same employer(s) provided payroll information. In Panel B, eligible active workers (EAW) are persons eligible for contributions (at least one employer) and inferred to be actively working on June 29, 2019. Individuals eligible for contributions have passed the background check and the 30-day enrollment window (at the same employer(s)), which provided payroll information for at least one employee at the firm. Suspended contributors are EAWs with a positive balance but no monthly contributions in June 2019. Contributors are EAWs with a positive balance and positive monthly contributions in June 2019.

Table 3: Summary Statistics for Individuals with a Positive Account Balance, June 2019

	N	$
Panel A: All individuals with a positive balance		
All individuals with a positive balance	40,652	–
Opted-out individuals with a positive balance	3,409	–
Participating individuals with a positive balance	37,243	–
Average balance if positive	–	558
Total assets	–	22.7 million
Panel B: Eligible active workers (EAW) with a positive balance		
EAWs with a positive balance	28,083	–
Opted-out EAWs with a positive balance	3,303	–
Participating EAWs with a positive balance	24,780	–
Average balance if positive	–	653

Note: Data from anonymized administrative records on June 29, 2019. Panel A reports statistics for all individuals ever had access to OregonSaves with a positive balance on June 29, 2019. Opted-out individuals with a positive balance are persons who opted out of the program before June 29, 2019 but had ever contributed and did not withdraw all contributions. Participating individuals with a positive balance are persons who were participating in the program on June 29, 2019, had ever contributed, and did not withdraw all contributions. Panel B presents statistics for eligible active workers (EAW) with a positive balance on June 29, 2019. EAWs are persons eligible for contributions (at least one employer) and inferred to be actively working on June 29, 2019. Individuals eligible for contributions have passed the background check and the 30-day enrollment window (at the same employer(s)), which provided payroll information for at least one employee at the firm.

Table 4: Distribution of OregonSaves Contribution Rates for Eligible Active Workers (EAW), June 2019

Contribution rate (%)	N. EAW	Percent of EAW (%)
0	52,852	69.1
1	512	0.7
2	546	0.7
3	824	1.1
4	181	0.2
5	16,875	22.1
6	4,038	5.3
7	80	0.1
8	90	0.1
9	14	0.0
10	332	0.4
>10	94	0.1
Total	76,438	100

Note: Data from anonymized administrative records on June 29, 2019. The contribution rate refers to the average contribution rate of all current employers where employees are eligible and active workers. These include employees who have opted out in the zero contribution rate bin if they are EAW. About 22.1% of EAW had contribution rates of 5%. About 5.3% had contribution rates of 6%, a large fraction of which can be attributed to the automatic escalation feature of the plan. On January 1, 2019, workers who had opened their accounts for six months were eligible for auto-escalation. The rates automatically increased by 1 percent unless workers actively chose to opt out of the auto-escalation arrangement.

Table 5: Reasons for Opting Out Provided by Eligible Active Workers (EAW), June 2019

Panel A: Main reasons	N	%
I can't afford to save at this time	13,142	29.3
I don't qualify for a Roth IRA due to my income	214	0.5
I don't trust the financial markets	1,230	2.7
I have my own retirement plan	9,236	20.6
I would prefer a Traditional IRA	488	1.1
I'm not interested in contributing through this employer	6,468	14.4
I'm not satisfied with the investment options	773	1.7
Other	11,269	25.1
Did not specify	2,045	4.6
Total	44,865	100.0

Panel B: Sample explanations of "Other" reasons employees opted out

Characterization of responses	% of other	Verbatim quote
Left employment	Large	Quit job
Not interested	Large	Nunca
Retiring soon or already	Large	85 years old
Anti government	Noticeable	Babylon is falling. One Love. One Heart. What was built on the sand will not stand.
Anti opt out plan	Noticeable	Because you have no g#$am right to automatically sign me up for this bulls***.
Anti-social	Noticeable	not your dam buisness
Confused by plan	Noticeable	Because I dont want the government's ROTH IRA. Its going to be terrible compared to what I could get for the price with another competitor.
Fees are too high	Noticaeble	1.01% return on my money. but a 1% yearly fee....no thanks

Note: Data from anonymized administrative records as of June 29, 2019. Opted-out workers (N=44,865) include eligible active workers who opted out during the first 30-day enrollment window through all employers (immediate opted-out workers, N=27,743) and those who opted out anytime through all employers (delayed opted-out workers, N=17,122).

Table 6: Summary Statistics for Individuals Eligible for Automatic Escalation, June 2019

Panel A: All individuals eligible for auto escalation	N	%
Opted out of auto increase before notification on Dec 1, 2018	505	6.8
Opted out of auto increase after notification before taking into effect on Jan 1, 2019	781	10.6
Rate auto increased, actively opted out of the program end of June 2019 (6 months after auto increase)	2,217	30.0
Rate auto increased, then actively lowered rate end of June 2019	71	1.0
Rate auto increased, then actively raised rate by more than 1 percent end of June 2019	46	0.6
Rate auto increased by 1 percent end of June 2019	3,781	51.1
Total	7,401	100.0
Panel B: EAW eligible for auto escalation	N	%
Opted out of auto increase before notification on Dec 1, 2018	410	7.2
Opted out of auto increase after notification before taking into effect on Jan 1, 2019	776	13.6
Rate auto increased, actively opted out of the program end of June 2019 (6 months after auto increase)	610	10.7
Rate auto increased, then actively lowered rate end of June 2019	71	1.2
Rate auto increased, then actively raised rate by more than 1 percent end of June 2019	46	0.8
Rate auto increased by 1 percent end of June 2019	3,781	66.4
Total	5,694	100.0

Note: Data from anonymized administrative records as of June 29, 2019. On January 1, 2019, workers who had accounts open for six months were eligible for auto-escalation. Additionally, workers who initially elected any non-zero contribution rate (default or non-default) were eligible for auto-escalation. Contribution rates are automatically increased by 1 percent until they reached 10%, every year on January 1 for all eligible workers. Auto-escalation eligibles may actively opt out of the auto-escalation arrangement any time. Panel A shows subgroups of individuals eligible for auto-escalation. About 6.8% of them opted out of the auto-escalation option before the OregonSaves administrator sent a notification a month before auto escalation took into effect (Dec 1, 2018). About 10.6% opted out after they received the notification, and before it took into effect. About 30% opted out of the OregonSaves program at the end of six months after auto-escalation occurred (June 30, 2019). One percent lowered their rates while still contributing at the end of June 30, 2019; 0.6% raised their rates at the end of June 30, 2019; and 51.1% were unresponsive to auto-escalation. Panel B shows how eligible active workers eligible for auto-escalation responded. 66.4% accepted the auto-escalation arrangement.

Table 7: Distribution of Contribution Rates for Eligible Active Workers (EAW) Eligible for Automatic Escalation Before and After Automatic Escalation

	Before: Nov 2018		After: June 2019	
Contribution rate (%)	N	%	N	%
0	–	–	409	9.1
1	81	1.8	16	0.4
2	85	1.9	81	1.8
3	110	2.4	97	2.2
4	22	0.5	69	1.5
5	4,142	91.9	97	2.2
6	18	0.4	3,632	80.6
7	17	0.4	26	0.6
8	8	0.2	29	0.6
9	3	0.1	6	0.1
10	19	0.4	34	0.8
>10	3	0.1	12	0.3
Total	4,508	100.0	4,508	100.0

Note: Data from anonymized administrative records as of June 29, 2019. This table identifies the fraction of active and eligible workers (EAW) eligible for automatic escalation who did not opt out of the auto-escalation arrangement before it took into effect. There were 4,508 of EAWs included in this table, equal to the total EAWs eligible for auto-escalation (N=5,694 in Panel B of Table 6) minus EAWs eligibles who opted out of auto-escalation before it occurred (N = 1,186 = 410 + 776, first two rows in Panel B of Table 6, so that 4,508 = 5,694 - 1,186). November 2018 was the last month unaffected by auto-escalation. The OregonSaves administrator notified participants eligible for auto-escalation on December 1, 2018. Auto-escalation happened on January 1, 2019. The contribution rate refers to the average contribution rate of current employers where employees are eligible and active workers. Columns 2-3 present that, at the end of November 2018, 91.9% saved at the initial 5% default rate. Columns 3-4 show that, at the end of June 2019, 80.6% saved at the new 6% default rate in June 2019.

Table 8: Choice Sets to Identify Time Preferences from Survey Responses

Start date t (unit: year)	Delay length k (unit: year)	Total # of tokens	Token unit value sooner time a_t	Token unit value later time a_{t+k}	Annual interest rate $(1+r)$
0	1	100	100	100	1
0	1	100	99	100	1.01
0	1	100	98	100	1.02
0	1	100	95	100	1.05
0	2	100	100	100	1
0	2	100	99	100	1.01
0	2	100	98	100	1.02
0	2	100	95	100	1.05
1	1	100	100	100	1
1	1	100	99	100	1.01
1	1	100	98	100	1.02
1	1	100	95	100	1.05
1	2	100	100	100	1
1	2	100	99	100	1.01
1	2	100	98	100	1.02
1	2	100	95	100	1.05

Note: This table shows variations in starting times t, delay length k, and interest rates $(1+r)$ to identify the key parameters from survey responses (see text). These include the normative time preference δ, the behavioral time preference β, and the utility function curvature. The survey was conducted in June 2019 to participants and opted-out workers ever had access to OregonSaves. Survey questions are provided in Appendix D. Parameters of interest are identified using regression models specified in Equations (13) and (14). Estimation results are presented in Table 9.

Table 9: Parameter Estimates of Time Preferences and Utility Function Curvature

	(1) Estimates from Eq.(13)	(2) Estimates from Eq.(14)
Normative time preference δ	0.995	0.987
	(0.006)	(0.005)
Behavioral time preference λ	0.987	0.993
	(0.005)	(0.007)
CRRA curvature: α	0.501	
	(0.089)	
CARA curvature: ρ		2.033
		(0.374)
Observations	1,765	1,765
N. unique subjects	143	143

Note: Data from anonymized survey responses collected in June 2019. An online experimental survey was sent to 441 OregonSaves-eligible workers, including those who opted out and participating as of June 2019. There are 143 survey respondents who answered the time preference survey questions provided in Appendix D, and these respondents made 1,765 intertemporal decisions in total. Both columns present estimation results from two-limit Tobit maximum likelihood regressions. Column 1 shows estimates of the regression specification in the form of Equation (13) assuming constant relative risk aversion utility (CRRA). The annual background consumption $w = -1,040$ was set to equal to the negative of the minimum consumption level among all survey respondents. The average normative discount factor δ under CRRA is 0.995, and the average behavioral discount factor β under CRRA is 0.987. Column 2 shows estimates of the regression specification in the form of Equation (14) assuming constant absolute risk aversion utility (CARA). The average δ under CARA is 0.987 and the average β under CARA is 0.993. Standard deviations are in parentheses.

Table 10: Social Marginal Welfare Weight g Calculations

	l-type savers	h-type savers
Average annual income Z_s	\$24,487	\$36,257
Percent of type h_s	71.8%	6%
Primitive Pareto weight $\alpha_s = \frac{1}{Z_s}$	0.000041	0.000028
Aggregate weighted Pareto weight $\bar{\alpha} = \sum_{s=\{l,h\}} \alpha_s h_s$	0.000031	0.000031
Social marginal welfare weight $g_s = \frac{\alpha_s}{\bar{\alpha}}$	1.32	0.90

Notes: This table reports estimates of the social marginal welfare weights for l-type passive savers (preferred rates below the default) and for h-type passive savers (preferred rates above the default). The welfare weight for a given type g_s is the Pareto weight α_s normalized by the aggregate weighted Pareto weight $\bar{\alpha}$. The normalization ensures that the welfare weights g_s only depend on the relative difference in income across types but are independent of the absolute size of income within type. These calculations are based on two empirical assumptions. First, we use observed data when the default rate is 5% to estimate the welfare weights at the optimal default. Second, statistics on annual income and the percent of type for l-type passive savers are inferred from the average level of all savers who elected a rate below the default; statistics for h-type passive savers are inferred by the average level of all savers who elected a rate above the default. The income information for each type Z_s is imputed from the OregonSaves savings data in June 2019, where individual-level monthly income equals the contribution amount divided by the contribution rate. Only individuals with a positive contribution amount and a positive rate are taken into account due to the limitation of the imputation calculation. Imputed average annual income equals the average monthly income times 12. Following Saez (2002), the third row shows that the primitive Pareto weight α_s equals the inverse of income $\frac{1}{Z_s}$. The fourth row shows that the aggregate weighted Pareto weight is the primitive Pareto weight α_s weighted by the percent of each type h_s.

Table 11: Baseline Optimal Default Contribution Rate Calculations

Statistics	Values
Panel A: Statistics for l-type passive savers	
Semi-elasticity ϵ_l	-0.12
Normative time preference δ_l	0.995
Behavioral time preference β_l	0.982
Annual income Z_l	\$24,487
Social marginal welfare weight g_l	1.32
Preferred rate of passive savers on the margin s_l	0.04
Panel B: Statistics for h-type passive savers	
Semi-elasticity ϵ_h	0.17
Normative time preference δ_h	0.995
Behavioral time preference β_h	0.987
Annual income Z_h	\$36,257
Social marginal welfare weight g_h	0.90
Preferred rate of passive savers on the margin s_h	0.09
Panel C: Opt-out costs	
Money-metric cost of opting out of the default rate K	\$250
Fraction of normative opt-out cost π	0
Panel D: Optimal default rate	
Baseline optimal default rate r^*	8.4%

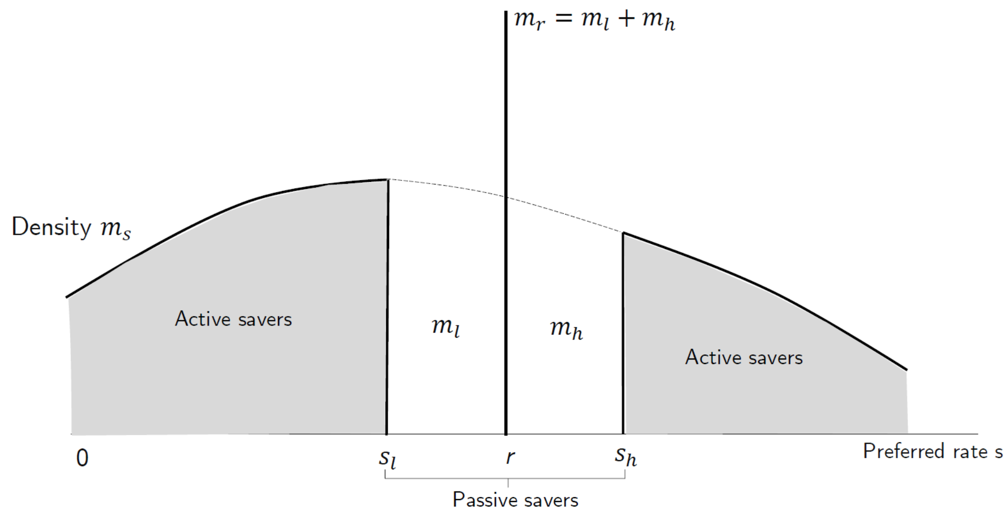
Notes: Estimates of key statistics used to compute the optimal default contribution rate in Proposition 3.2: All statistics in Panel A and Panel B are estimated from the OregonSaves data (see text) except that ϵ_h uses data from Beshears et al. (2012). Estimates for δ_l, β_1, δ_h, and β_h are identified using survey data collected from OregonSaves-eligible workers in Table 9 (see Section 4.2). Estimation procedures for g_l and g_h are are provided in Table 10. In Panel C, the value of K borrows from Choukhmane (2018). Calculation details for the baseline optimal default rate in Panel D are provided in Section 5.

Table 12: Optimal Default Contribution Rate Under Alternative Assumptions

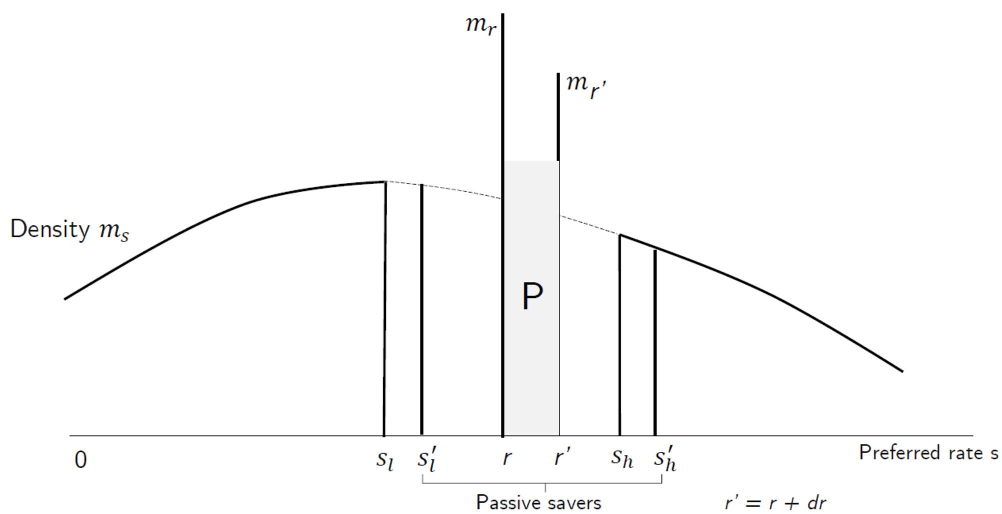
	Optimal default contribution rate (%)
Baseline	8.4
High present bias ($\beta_l = 0.45$)	8.2
Low long-run discount factor ($\delta_l = 0.7$)	8.5
Low elasticity to the default rate ($\epsilon_h = 0.12$)	8.4
Large perceived opt-out cost ($K = \$1,000$)	8.4

Notes: This table reports the optimal default contribution rate r^*, as computed using the sufficient statistics formula in Proposition 3.2 under different assumptions. The first row is the baseline calculation, which uses the estimates of statistics displayed in Table 11. The second row reports the optimal default rate under the assumption that individuals electing a low preferred rate are very present biased ($\beta_l = 0.45$ lower than the baseline value). The third row reports the optimal default rate under the assumption that individuals electing a low preferred rate have a low long-run discount factor ($\delta_l = 0.7$). The fourth row assumes that individuals with a high preferred rate are less responsive to the default rate than those in the baseline calculation ($\epsilon_h = 0.12$). The last row assumes that the average perceived cost of opting out of the default rate is higher than the value in the baseline calculation ($K = \$1,000$).

Figure 1: Impact of a Marginal Perturbation of the Default Savings Rate r

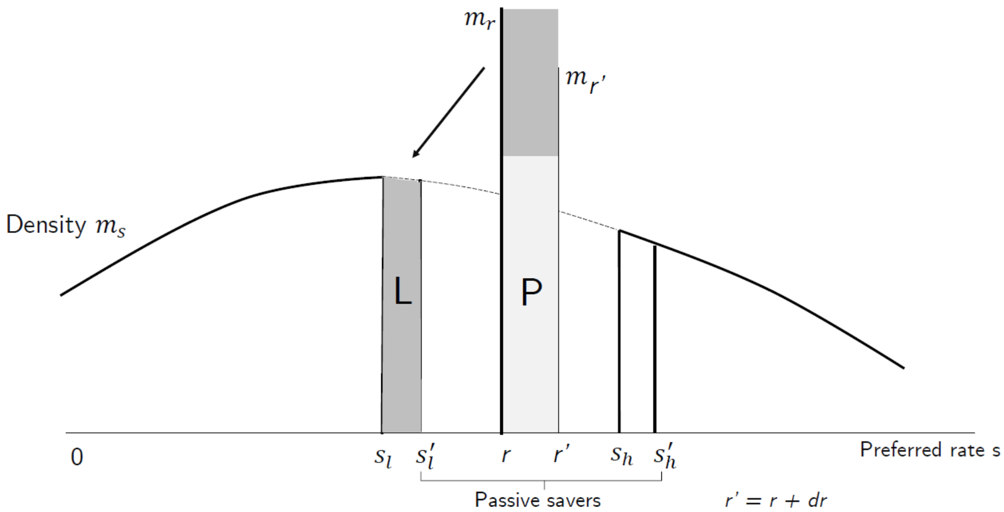


(a) In this figure, r is the default savings rate. Workers with a preferred savings rate between s_l and s_h save at the default rate r because the default is close to their preferred rates. These workers are defined as passive savers, with density $m_r = m_l + m_h$, where m_l are the fraction of passive savers with an underlying preferred rate between s_l and r, and m_h are the fraction of passive savers with an underlying preferred rate between r and s_h. Workers with a preferred rate below s_l or above s_h actively opt out of the default rate. They are defined as active savers.

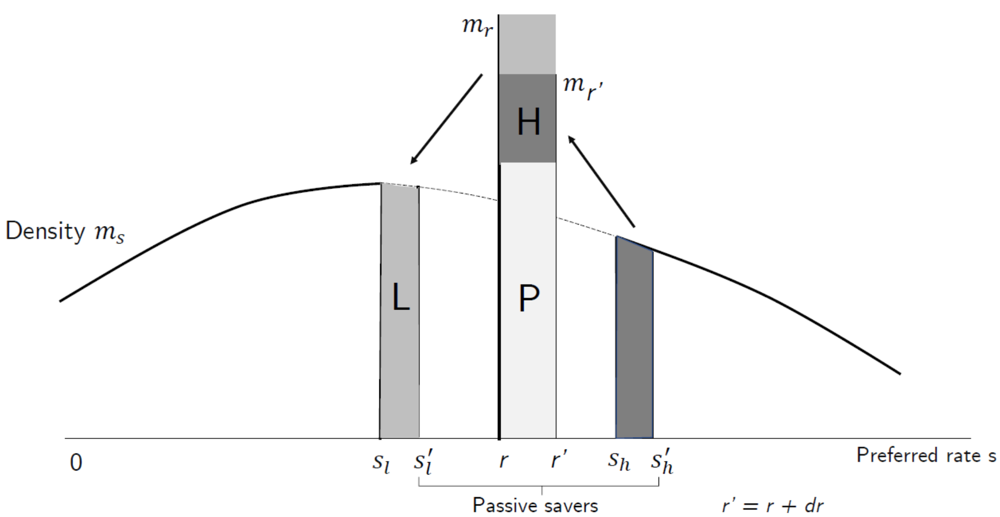


(b) Suppose the policymaker sets a default rate at r' instead of r, where $r' = r + dr$. When the default rate is r', passive savers are workers with a preferred savings rate between $s_l^{'}$ and $s_h^{'}$. Their preferred rates are close to the new default rate r'. The total density of passive savers is denoted by $m_r^{'}$. Active savers are workers with a preferred rate below $s_l^{'}$ or above $s_h^{'}$. The shaded rectangle, denoted by P, shows the fraction of workers who are passive savers both under r and r'. These are workers with a preferred rate between $s_l^{'}$ and s_h.

Figure 1: Continued



(c) The shaded area, denoted by L, indicates the fraction of workers who are passive savers under the low default rate r but active savers under the high default rate r'. These are workers with a preferred rate between s_l and $s_l^{'}$. They are passive savers under the low default r because it is close enough to their preferred rates. They opt out of the high default r' and become active savers because the high default r' is far from their preferred rate.



(d) The shaded area, denoted by H, shows the fraction of workers who are active savers under the low default rate r but passive savers under the high default rate r'. These are workers with a preferred rate between s_h and $s_h^{'}$. They are active savers under the low default r because the low default is far from their preferred rates. They are passive savers under the high default r' because the high default is close enough to their preferred rates.

Appendix

A Microfoundation of the Preferred Saving Rate θ

The preferred saving rate, denoted θ, is the non-default rate that individuals would choose if they opt out of the default savings rate. The preferred saving rate θ is chosen from a policy space $\tilde{\theta} \in [0, 1]$, where θ maximizes the following utility function:

$$\theta = \arg\max_{\tilde{\theta}} U(\tilde{\theta}) = \arg\max_{\tilde{\theta}} u((1 - \tilde{\theta}) \cdot Z) + \gamma\delta v(\tilde{\theta} \cdot Z) - K, \tag{15}$$

where Z is the labor income, γ is the behavioral time preference, δ is the normative time preference, and K is the perceived cost of making an active decision. See Section 3 for detailed descriptions of these variables. Workers who choose θ as their preferred saving rate are defined as type-θ workers.

For a given type-θ worker, her preferred consumption amount $C(\theta) = (1 - \theta)Z(\theta)$, and preferred savings amount $S(\theta) = \theta Z(\theta)$. When there is a default savings rate r, she decides her pension saving amount $P(\theta)$ between two options: the default savings amount $R(\theta) = r \cdot Z(\theta)$ and her preferred saving amount $S(\theta)$. Her observed choice of saving amount in the presence of a default rate r maximizes Equation (1) in Section 3.

B Proof of Proposition 3.2

The first-order condition for the social welfare function, Equation (3), equals zero at the optimal default rate r^*:

$$\begin{aligned}\frac{dW(r^*)}{dr} &= \frac{d}{dr}\int_{\theta=\theta_l}^{\theta_h} \alpha(\theta)N(P(\theta))dm(\theta) \\ &\approx \int_{\theta=\theta_l}^{\theta_h} \alpha(\theta)\frac{dN(R^*(\theta))}{dr}dm(\theta) + \frac{dm_h}{dr}\alpha_h(N(R_h) - N(S_h)) - \frac{dm_l}{dr}\alpha_l(N(S_l) - N(R_l)) \qquad (16) \\ &= 0.\end{aligned}$$

The first term in Equation (16) can be decomposed into two terms:

$$\begin{aligned}&\int_{\theta=\theta_l}^{\theta_h} \alpha(\theta)\frac{dN(R^*(\theta))}{dr}dm(\theta) \\ &\approx \int_{\theta_l}^{r^*} \alpha_l\frac{dN(R_l^*)}{dr}dm_l + \int_{r^*}^{\theta_h} \alpha_h\frac{dN(R_h^*)}{dr}dm_h \\ &= \alpha_l\frac{dN(R_l^*)}{dr}m_l + \alpha_h\frac{dN(R_h^*)}{dr}m_h \\ &= \alpha_l\frac{dN}{dR_l^*}\frac{dR_l^*}{dr}m_l + \alpha_h\frac{dN}{dR_h^*}\frac{dR_h^*}{dr}m_h \\ &= \alpha_l\frac{dN}{dR_l^*}Z_l m_l + \alpha_h\frac{dN}{dR_h^*}Z_h m_h, \qquad (17)\end{aligned}$$

where $R_l^* = r^* \cdot Z_l$ so that $\frac{dR_l^*}{dr} = Z_l$. Based on Equation (2) that $N = U + (1-\gamma_l)\delta_l v(R_l^*)$, the partial derivative $\frac{dN}{dR_l^*}$ can be rewritten as:

$$\begin{aligned}\frac{dN}{dR_l^*} =& \frac{d}{dR_l^*}(U + (1-\gamma_l)\delta_l v(R_l^*)) \\ =&(1-\gamma_l)\delta_l v'_{R_l^*} \\ =&(1-\gamma_l)\delta_l\frac{g_l\lambda}{\alpha_l}, \qquad (18)\end{aligned}$$

where $g_l := \frac{\alpha_l v'_{R_l^*}}{\lambda}$ as defined in Equation (5) and $v'_{R_l^*} := \frac{dv(R_l^*)}{dR_l^*}$. Similarly, $\frac{dN}{dR_h^*} = (1-\gamma_h)\delta_h \frac{g_h \lambda}{\alpha_h}$. Combining Equations (17) and (18), we rewrite the first term in Equation (16) as:

$$\begin{aligned}
&\int_{\theta=\theta_l}^{\theta_h} \alpha(\theta) \frac{dN(R^*(\theta))}{dr} dm(\theta) \\
\approx &\alpha_l \frac{\partial N}{\partial R_l^*} Z_l m_l + \alpha_h \frac{\partial N}{\partial R_h^*} Z_h m_h \\
= &(1-\gamma_l)\delta_l g_l \lambda Z_l m_l + (1-\gamma_h)\delta_h g_h \lambda Z_h m_h. \qquad (19)
\end{aligned}$$

Based on Equation (2) that $N = U + (1-\gamma(\theta))\delta(\theta)v(P(\theta)) + (1-\pi)K\mathbf{1}\{P(\theta) = S(\theta)\}$, where $P(\theta) \in \{R(\theta), S(\theta)\}$ and $\theta \in \{h, l\}$, the second term in Equation (16) can be rewritten as:

$$\begin{aligned}
&\frac{dm_h}{dr}\alpha_h (N(R_h) - N(S_h)) \\
= &\frac{dm_h}{dr}\alpha_h \Big(U(R_h) + (1-\gamma_h)\delta_h v(R_h) - U(S_h) - (1-\gamma_h)\delta_h v(S_h) - (1-\pi)K \Big) \\
= &\frac{dm_h}{dr}\alpha_h \Big((1-\gamma_h)\delta_h (v(R_h) - v(S_h)) - (1-\pi)K \Big). \qquad (20)
\end{aligned}$$

Workers on the margin of switching to their preferred saving amount $S_h (= \theta_h Z_h)$ are indifferent between saving at the default and their preference when they evaluate these two choices using the decision utility U. The same argument was applied in the optimal taxation literature in Saez (2002). Therefore, $U(R_h) = U(S_h)$. Based on Assumption (4) that $v(R_h) = R_h$ and the definition of g_h in Equation (5), $\alpha_h = \frac{g_h \lambda}{v'_{R_h}} = g_h \lambda$. Equation (20) can be expressed as:

$$
\begin{aligned}
&\frac{dm_h}{dr}\alpha_h(N(R_h)-N(S_h)) \\
=&\frac{dm_h}{dr}\alpha_h\Big((1-\gamma_h)\delta_h(v(R_h)-v(S_h))-(1-\pi)K\Big) \\
=&\frac{dm_h}{dr}\alpha_h\Big((1-\gamma_h)\delta_h(R_h-S_h)-(1-\pi)K\Big) \\
=&\frac{dm_h}{dr}g_h\lambda\Big((1-\gamma_h)\delta_h(r^*-\theta_h)Z_h-(1-\pi)K\Big). \qquad (21)
\end{aligned}
$$

Similarly, the third term in Equation (16) can be expressed as:

$$
\begin{aligned}
&\frac{dm_l}{dr}\alpha_l(N(S_l)-N(R_l)) \\
=&\frac{dm_l}{dr}\alpha_l\Big(U(S_l)+(1-\gamma_l)\delta_l S_l+(1-\pi)K-U(R_l)-(1-\gamma_l)\delta_l R_l\Big) \\
=&\frac{dm_l}{dr}g_l\lambda\Big((1-\gamma_l)\delta_l(\theta_l-r^*)Z_l+(1-\pi)K\Big). \qquad (22)
\end{aligned}
$$

Combining Equations (19), (21), and (22), we get

$$
\begin{aligned}
\frac{dW(r^*)}{dr} =&(1-\gamma_l)\delta_l g_l\lambda Z_l m_l+(1-\gamma_h)\delta_h g_h\lambda Z_h m_h \\
&+\frac{dm_h}{dr}g_h\lambda\Big((1-\gamma_h)\delta_h(r^*-\theta_h)Z_h-(1-\pi)K\Big) \\
&-\frac{dm_l}{dr}g_l\lambda\Big((1-\gamma_l)\delta_l(\theta_l-r^*)Z_l+(1-\pi)K\Big) \qquad (23) \\
=&0.
\end{aligned}
$$

We rearrange Equation (23) and plug in semi-elasticities $\epsilon_l = \frac{dm_l}{dr}\frac{1}{m_r}$ and $\epsilon_h = \frac{dm_h}{dr}\frac{1}{m_r}$:

$$\begin{aligned}
&\frac{dW(r^*)}{dr} \\
&= (1-\gamma_l)\delta_l g_l Z_l m_l - \frac{dm_l}{dr} g_l(1-\gamma_l)\delta_l(\theta_l - r^*)Z_l - \frac{dm_l}{dr} g_l(1-\pi)K \\
&+ (1-\gamma_h)\delta_h g_h Z_h m_h + \frac{dm_h}{dr} g_h(1-\gamma_h)\delta_h(r^* - \theta_h)Z_h - \frac{dm_h}{dr} g_h(1-\pi)K \\
&= 0 \\
&(1-\gamma_l)\delta_l g_l Z_l \frac{m_l}{m_r} + |\epsilon_l| g_l(1-\gamma_l)\delta_l(\theta_l - r^*)Z_l + |\epsilon_l| g_l(1-\pi)K \\
&+ (1-\gamma_h)\delta_h g_h Z_h \frac{m_h}{m_r} + |\epsilon_h| g_h(1-\gamma_h)\delta_h(r^* - \theta_h)Z_h - |\epsilon_h| g_h(1-\pi)K \\
&= 0,
\end{aligned}$$

where $\epsilon_l = \frac{dm_l}{dr}\frac{1}{m_r} < 0$ and $\epsilon_h = \frac{dm_h}{dr}\frac{1}{m_r} > 0$ by definition. The overall welfare effect can be decomposed into several terms after the default savings rate marginally increases from r^* to $r^* + dr$:

1. The aggregate weighted welfare gain to all passive savers on the intensive margin is $dI = (1-\gamma_l)\delta_l g_l Z_l \frac{m_l}{m_r} + (1-\gamma_h)\delta_h g_h Z_h \frac{m_h}{m_r}$.

2. The welfare gain to l-type workers for switching to their preferred rate θ_l under the new default $r^* + dr$ is $dS_l = |\epsilon_l| g_l(1-\gamma_l)\delta_l\theta_l Z_l$.

3. The welfare loss to l-type workers for opting out of the default rate is $dR_l = |\epsilon_l| g_l(1-\gamma_l)\delta_l Z_l$.

4. The welfare loss to h-type workers for no longer saving at their preferred rate θ_h is $dS_h = |\epsilon_h| g_h(1-\gamma_h)\delta_h\theta_h Z_h$.

5. The welfare gain to h-type workers for starting to save at the default rate is $dR_h = |\epsilon_h| g_h(1-\gamma_h)\delta_h Z_h$.

6. The welfare gain to l-type workers for making an active choice is $dK_l = |\epsilon_l| g_l (1-\pi)K$.

7. The welfare loss to h-type workers for no longer making an active choice is $dK_h = |\epsilon_h| g_h (1-\pi)K$.

Rearranging the last equation, we solve for the optimal default rate r^*:

$$r^* = \frac{dI + dS_l - dS_h + dK_l - dK_h}{dR_l - dR_h}.$$

C Distributions of Contribution Rates from Beshears et al. (2012) to Identify Semi-Elasticities in Section 4.1.2

Description from Beshears et al. (2012): Figure 3. The Distribution of Employee Contribution Rates at Firm C with a 3% Default. This figure gives the distribution of employee contribution rates at one year of tenure at Firm C when there was a 3% default contribution rate. The sample is the 2,785 full-time employees who were hired at the firm between January 1, 2003 and February 29, 2004, who remained at the firm for at least one year, and who were not Highly Compensated Employees. The default contribution rate was 3%, and the minimum contribution rate necessary to obtain the full employer match was 7%.

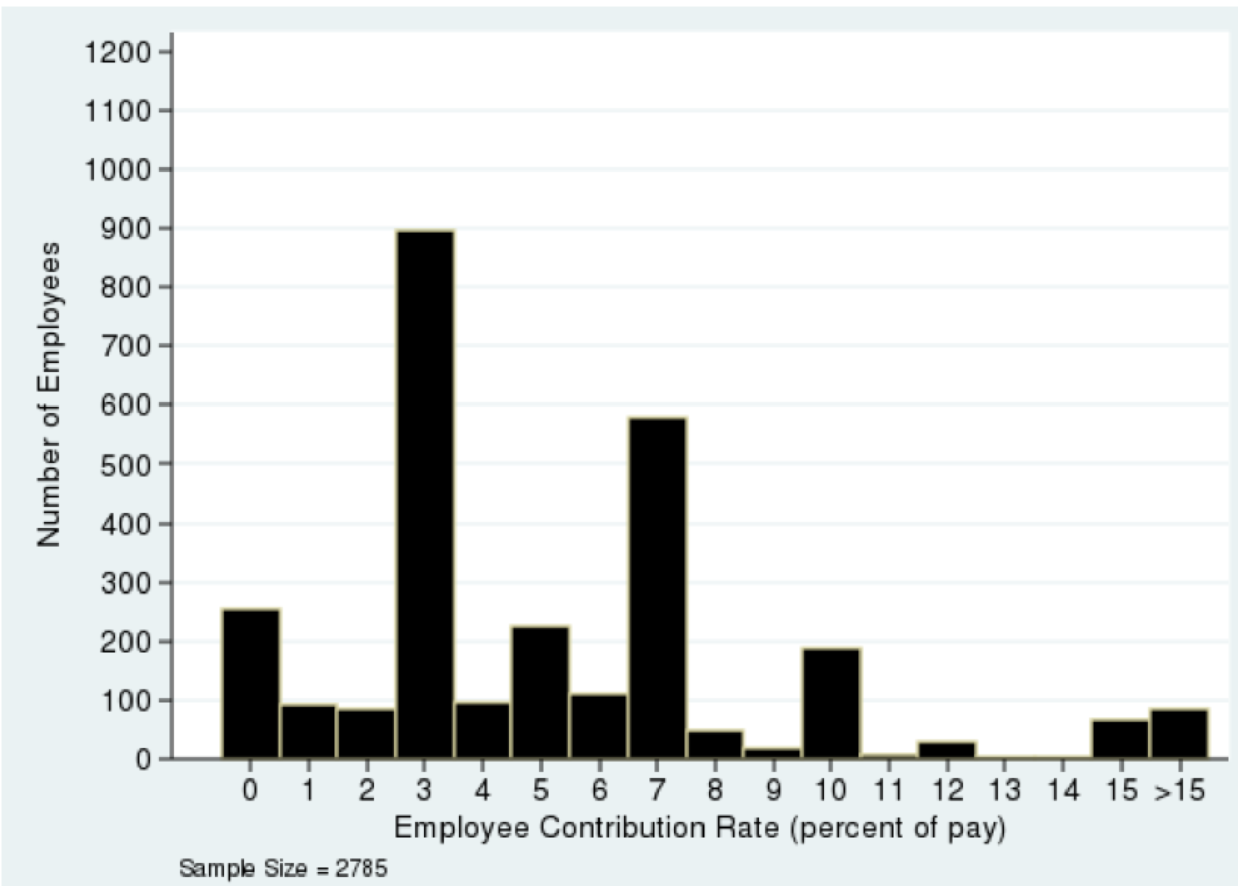
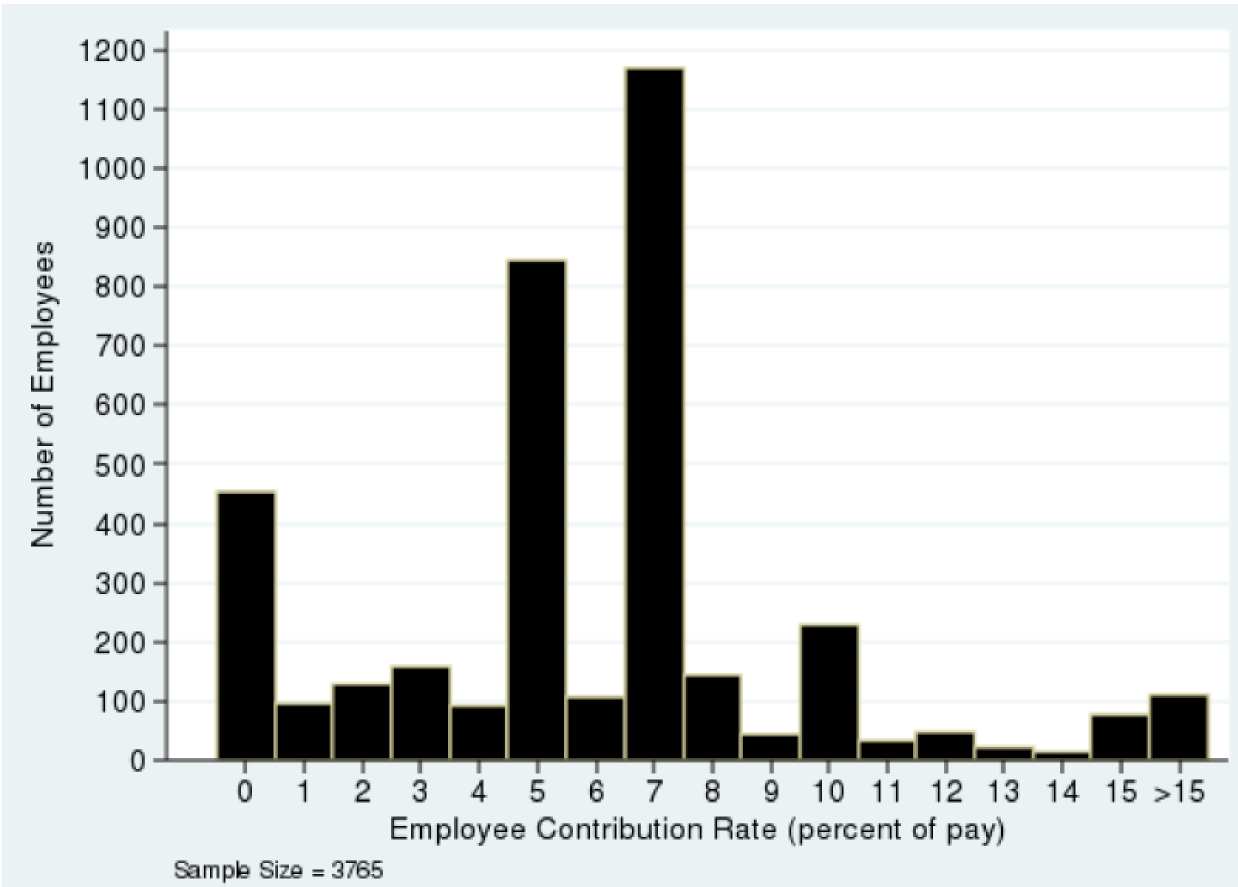


Figure 4. The Distribution of Employee Contribution Rates at Firm C with a 5% Default. This figure gives the distribution of employee contribution rates at one year of tenure at Firm C when there was a 5% default contribution rate. The sample is the 3,765 full-time employees who were hired at the firm between June 1, 2005 and July 31, 2006, who remained at the firm for at least one year, and who were not Highly Compensated Employees. The default contribution rate was 5%, and the minimum contribution rate necessary to obtain the full employer match was 7%.



D Survey Questions to Elicit Time Preferences

Survey design and results are explained in Section 4.2, Table 8, and Table 9.

oregonsaves

OregonSaves Follow-Up Survey

Instructions: The following questions are all hypothetical, and your answers will not affect the amount of the gift card you will receive by completing the survey. In each of the following questions, please tell us how you think about tradeoffs between today and the future, by moving the slider. We ask you in each case to click the slider dividing 100 tokens between two dates. Here is an example:

Each token is worth $95 today and $100 in a year. How many tokens would you want to receive today?	0	70	100
Amount you will have today	$ 6,650	
Amount you will have in a year	$ 3,000	

This example shows how someone could divide 100 tokens between 70 today and 30 for a year from today. Each token today is worth $95, while each token for a year from today is worth $100. So this person would choose to receive 70*$95=$6,650 today and 30*$100=$3,000 a year from today.

Please use the slider to select the number of tokens you would like to receive today.

1. Each token is worth $100 today and $100 in a year. How many tokens would you want to receive today? 0 — 0 — 100
1. Amount you will have today
1. Amount you will have in a year

2. Each token is worth $99 today and $100 in a year. How many tokens would you want to receive today? 0 — 0 — 100
2. Amount you will have today
2. Amount you will have in a year

3. Each token is worth $98 today and $100 in a year. How many tokens would you want to receive today? 0 — 0 — 100
3. Amount you will have today
3. Amount you will have in a year

4. Each token is worth $95 today and $100 in a year. How many tokens would you want to receive today? 0 — 0 — 100
4. Amount you will have today
4. Amount you will have in a year

Survey navigation:
Next will advance you to the following question. After the last question, be sure to select Submit to complete the survey.

Completed:

OregonSaves Follow-Up Survey

Please use the slider to select the number of tokens you would like to receive today.

1. Each token is worth $100 today and $100 in two years. How many tokens would you want to receive today?	0	0	100
1. Amount you will have today			
1. Amount you will have in two years			
2. Each token is worth $99 today and $100 in two years. How many tokens would you want to receive today?	0	0	100
2. Amount you will have today			
2. Amount you will have in two years			
3. Each token is worth $98 today and $100 in two years. How many tokens would you want to receive today?	0	0	100
3. Amount you will have today			
3. Amount you will have in two years			
4. Each token is worth $95 today and $100 in two years. How many tokens would you want to receive today?	0	0	100
4. Amount you will have today			
4. Amount you will have in two years			

Survey navigation:
Next will advance you to the following question. After the last question, be sure to select Submit to complete the survey.

Completed:

OregonSaves Follow-Up Survey

Please use the slider to select the number of tokens you would like to receive in a year.

1. Each token is worth $99 today and $100 in a year. How many tokens would you want to receive today? 0 **0** 100

1. Amount you will have in a year

1. Amount you will have in two years

2. Each token is worth $98 today and $100 in a year. How many tokens would you want to receive today? 0 **0** 100

2. Amount you will have in a year

2. Amount you will have in two years

3. Each token is worth $97 today and $100 in a year. How many tokens would you want to receive today? 0 **0** 100

3. Amount you will have in a year

3. Amount you will have in two years

4. Each token is worth $95 today and $100 in a year. How many tokens would you want to receive today? 0 **0** 100

4. Amount you will have in a year

4. Amount you will have in two years

Survey navigation:
Next will advance you to the following question. After the last question, be sure to select Submit to complete the survey.

Completed:

OregonSaves Follow-Up Survey

Please use the slider to select the number of tokens you would like to receive in a year.

1. Each token is worth $100 in a year and $100 in three years. How many tokens would you want to receive today? 0 **0** 100

1. Amount you will have in a year

1. Amount you will have in three years

2. Each token is worth $99 in a year and $100 in three years. How many tokens would you want to receive today? 0 **0** 100

2. Amount you will have in a year

2. Amount you will have in three years

3. Each token is worth $98 in a year and $100 in three years. How many tokens would you want to receive today? 0 **0** 100

3. Amount you will have in a year

3. Amount you will have in three years

4. Each token is worth $95 in a year and $100 in three years. How many tokens would you want to receive today? 0 **0** 100

4. Amount you will have in a year

4. Amount you will have in three years

Survey navigation:
Next will advance you to the following question. After the last question, be sure to select Submit to complete the survey.

Completed: