Optimal Default Retirement Saving Policies: Theory and Evidence from OregonSaves

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Abstract

Many U.S. states are launching state-sponsored auto-enrollment retirement plans, with the goal of boosting retirement savings among private-sector workers lacking access to employer-sponsored retirement plans. This paper provides an analysis of state-sponsored auto-enrollment plans, and specifically, the plan's default contribution rate. We develop a tractable framework to derive the optimal default contribution rate taking into account workers' decisions on adhering to the default contribution rate. The optimal default contribution rate is shaped by the social benefits of increased savings due to adherence to the default that keeps workers from undersaving, while reducing reliance on means-tested social transfers. The optimal default contribution rate is also counterbalanced by the social benefits of action when an undesirable default option compels workers to make an active decision. To estimate these counterbalancing social welfare forces, we use individual-level administrative and survey data from OregonSaves, the state-sponsored plan offered by the Oregon state government, and suggest the optimal default contribution rate to be 8%.

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1 Introduction

While employer-sponsored automatic enrollment retirement plans such as 401(k) and 403(b) programs have become the main vehicle for retirement savings, only about half of the U.S. private-sector workforce currently has access to such plans. This situation has prompted more than half of all U.S. states to consider mandating that private-sector firms without employer-sponsored plans enroll their employees in a state-sponsored auto-enrollment plan.[1] Although the purpose of expanding access to auto-enrollment plans is to increase retirement savings, the mere availability of a retirement savings plan is not guaranteed to be effective in encouraging retirement savings for two main reasons. First, when low-income workers gain access to save, they might not be able to afford to save due to liquidity constraints. Second, low- and mid-income workers might not wish to save, as personal savings could crowd out their eligibility for means-tested social transfers in retirement. It is thus crucial that state-sponsored auto-enrollment plans be carefully designed to consider the liquidity constraints as well as the crowd-out effect between personal savings and social support from means-tested social transfers.

This paper focuses on the optimal design of the default contribution rate in state-sponsored auto-enrollment plans, as it is one of the key policy considerations shaping workers' saving decisions. We use sufficient statistics to capture how liquidity constraints and the crowd-out effect of retirement savings *perceived* by workers impact their decisions to accept the default contribution rate. Based on the sufficient statistics capturing workers' responses to the default contribution rate, we develop a tractable framework for analyzing the welfare impacts of the default contribution rate. In the welfare framework, we take into account the *actual* crowd-out between retirement savings and means-tested social benefits if accepting

[1] State governments impose a mandate on employers so that employers are required to provide employees access to either employer-sponsored or state-sponsored auto-enrollment plans. Employees who are automatically enrolled in a plan are not required to participate. A typical auto-enrollment plan allows employees to opt out anytime.

the default contribution rate effectively increases workers' savings. We ultimately derive the first explicit formula of the optimal default contribution rate from the welfare framework, empirically estimate key determinants in the formula, and provide direct policy guidance for setting the default contribution rate in state-sponsored auto-enrollment plans.

Using individual-level administrative data from the first state-sponsored plan in the United States launched in 2017, OregonSaves, we identify how workers respond to the default contribution rate when given access. While extensive previous research has examined the effect of default contributions, the causal effect of the default contribution 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 under the influence of both the default rate and employer matching. Given that OregonSaves does not allow employer matching, it provides a unique opportunity to tease out the causal effect of the default contribution rate on retirement savings. We express the causal effect in terms of sufficient statistics and directly map them to the core welfare analysis in this paper, which derives the optimal level of the default contribution rate.

Taking into account workers' responses to the default contribution rate, we characterize the social welfare tradeoff that the policymaker faces when setting the default contribution rate. On the one hand, the policymaker aims to help low- and mid- income workers accumulate personal savings as long as they can afford to save. This objective has the additional benefit of potentially reducing public expenditures on means-tested social transfers,[2] as low- and mid- income workers with personal retirement savings may rely less on social support.

[2]Some of the major means-tested social transfers for senior citizens are Medicaid, Supplemental Security Income, and Supplemental Nutrition Assistance Program (SNAP). All of them have income and asset limits. See Moffitt (2018) for details.

To achieve the goal of substituting personal retirement income sources for public sources, the policymaker should set the default contribution rate relatively low to keep workers from opting out of the default, even when workers might not fully appreciate the long-term value of savings in the present. On the other hand, if setting the default contribution rate to an undesirably high level effectively prompt people to overcome procrastination, the policymaker should raise the default rate to encourage more people to make an active choice that fits their own long-term saving goals. We express these two counterbalancing forces in an explicit formula of the optimal default contribution rate. Additionally, we characterize these forces in terms of statistics that can be empirically estimated, and ultimately compute the optimal level of the default contribution rate.

We first empirically estimate the effectiveness of the default contribution rate in encouraging savings among passive savers (i.e., those who accept the default rate). We conduct an online survey to elicit the time preferences of OregonSaves-eligible workers, in which we find that on average workers weakly prefer spending most of their income now over spreading out the income between now and later. In other words, the effectiveness of the default among passive savers on increasing savings would be relatively moderate. Moreover, we evaluate the social value of each additional dollar of savings by income, as an extra dollar of savings of low-income workers are more likely to reduce public expenditures on means-tested social transfers than that of high-income workers. We also quantify the welfare effect of the default contribution rate on active savers (i.e., those who elect a non-default rate) by referring to the previous literature (Choukhmane, 2018). Active savers contribute to social welfare in that they save public resources to incentivize them to take action. They overcome procrastination and pay attention to their saving decisions solely because the default rate is far from their preferred rates. Combining these two forces, a baseline calculation suggests that the optimal default contribution rate is 8%.

The analysis of the optimal design of default saving policies extends our understanding of the power of public policy for improving the efficiency of redistribution. Unlike conventional income transfer policies (e.g., taxation, cash transfers, and in-kind transfers) that redistribute a large amount of public resources across people, default saving policies usually involve indirect policy suggestions that influence individual behavior without transferring public resources. Under the influence of default saving policies, the majority of the population will take on their personal responsibilities to support their own retirement. As a result, public resources in means-tested social programs could be redistributed to people who need them the most.

Contributions to the Literature. Our welfare analysis of the default contribution rate is related to three strands of literature. First, the optimal design of default retirement saving policies – the default contribution 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 contribution rate should be set at the employer matching cap in an employer-sponsored retirement plan. Goldin and Reck (2018) extended that analysis by comparing the welfare consequences between saving at the default and making a suboptimal active decision. Our paper establishes a broader social context for the analysis of the optimal default rate by taking into account the interaction between private savings and eligibility for means-tested welfare programs. Additionally, we 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. Our formula complements Bernheim et al. (2015), as we evaluate the optimal default contribution rate in a retirement plan without employer matching.

This paper also contributes to the literature on a sufficient statistics approach for optimal public policy. We extend the applicability of the sufficient statistics approach to "nudge" policies, and in particular the default retirement saving rate. Farhi and Gabaix (2019) discussed optimal nudges in taxation, while we focus on optimal nudges in the context of default saving policies. We specifically provide a tractable microfoundation for one type of sufficient statistics, social marginal welfare weights, in the context of default saving policies. One type of social marginal welfare weights characterizes the *policymaker's* redistributive preference, which is taken as given (Saez, 2002; Saez and Stantcheva, 2016). The other type introduced by Hendren (2017), called efficient welfare weights, characterizes the distortionary cost generated by *individuals* which can be estimated from data.[3] That distortionary cost (e.g., individuals decrease their income to maximize tax credits) generates fiscal externalities. In this paper, we explore another type of fiscal externalities that can also be captured by the welfare weights, which is the substitution between private savings and means-tested social transfers. When individuals increase their savings under the influence of default saving policy, they generate a positive fiscal externality by reducing public expenditures on means-tested welfare programs.

Our work 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 we provide an alternative explanation: one reason people do not save is because they are not *automatically* enrolled in a savings plan. The second question we address is 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, we 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

[3]Finkelstein (2019) provides an extensive discussion on the interpretation and applications of Hendren (2017).

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

2 An Overview of OregonSaves

In this section, we 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. 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) contribution 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[4] 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 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 if they hold multiple jobs. Additionally, their accounts also follow them as they move from one job to another. 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 retire-

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

ment plans in seven waves. A first wave of firms volunteered to be in the pilot program, followed by six compulsory waves. Employer waves are 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. From January 1, 2020, an employer penalty will be levied on companies that do not provide access to their own retirement plans or to OregonSaves for employees.

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, we present empirical evidence on (a) the impact of OregonSaves on expanding access to workplace retirement savings programs, (b) the characteristics of employers required to provide 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 contribution rates on participation and contributions.[5]

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

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 their personal 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. It is our understanding that the large number of workers in health care can best described as home-health care workers. Finance, insurance, and managements 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, yet their employers had not 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 we 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 we have access, we 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, we 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 we 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 having 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 contribution rate, we 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, we 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 we 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 contribution rates to zero.

Table 4 presents the distribution of contribution 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 contribution 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 contribution 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 contribution 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.[6]

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 contribution rates (default or non-default) were eligible for auto-escalation. Similar to the initial default contribution rate, eligibles could actively opt out of the auto-escalation arrangement; if they did not, contribution 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

[6]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.

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 contribution 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 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 contribution 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 contribution 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 Contribution Rate

Optimally designing the default contribution 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, we 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, each worker divides her labor income Z between consumption in the work life and savings for retirement. Each worker has a preferred consumption amount $C = (1-s)Z$, and a preferred saving amount $S = sZ$, where s corresponds to her preferred saving rate. (Throughout this paper, we will use uppercase letters to denote levels and lowercase letters to denote rates.) Formally, s maximizes the intertemporal decision utility: $U(C, S) = u(C) + \beta\delta v(S) - K$.[7] We define that 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 β captures the behavioral reasons to underestimate future utility (e.g. time inconsistency or misinformation). The variable K represents the perceived disutility of taking action to set up a retirement account and elect the preferred rates s; we assume the disutility cost K is homogeneous across the population. To simplify notation, we define workers having the same preferred rate s as the same type, where s captures heterogeneity in time preferences and labor income:

[7] The preferred rate $s = \arg\max_{\tilde{s}} u(\tilde{C}(\tilde{s})) + \beta\delta v(\tilde{S}(\tilde{s})) - K$, where $\tilde{C} = (1-\tilde{s})Z$, and $\tilde{S} = \tilde{s}Z$. The preferred consumption amount C and the preferred saving amount S are the maximands of the decision utility: $\{C, S\} = \arg\max_{\{\tilde{C},\tilde{S}\}} u(\tilde{C}) + \beta\delta v(\tilde{S}) - K$. Additionally, we make two simplifications about the return on savings. The investment return of savings is risk-free, and the investment return is offset by inflation so that the real value of savings is S in terms of the dollar value in the first period.

$s := (\delta, \beta, Z)$. The density of each type is denoted by m_s.

We then assume a policymaker launches an automatic enrollment retirement savings program with a default contribution rate $r \in (0, 1]$. The default saving amount for a given type of workers with earnings Z_s is $R_s = rZ_s$. Each type of workers chooses their pension savings P_s between two discrete options: the preferred saving amount S_s or the default saving amount R_s. The indirect decision utility function for a type-s worker in the presence of a default rate r is expressed as:

$$U(C_s, P_s; s, r, K) = u(C_s) + \beta_s \delta_s v(P_s) - K\mathbf{1}\{P_s \neq R_s\}, \tag{1}$$

where $C_s + P_s = Z_s$ and $P_s \in \{S_s, R_s\}$. 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. We will refer to K as the opt-out costs,[8] which include but are not limited to time and psychological costs of switching from the default rate to worker's preferred rate. We assume that the preferred saving rate s, 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 from decision utility U. The indirect normative utility function N is formally expressed as:

$$\begin{aligned} N(C_s, P_s; s, r, K, \pi) &= u(C_s) + \delta_s v(P_s) - \pi K\mathbf{1}\{P_s \neq R_s\} \\ &= U + (1 - \beta_s)\delta_s v(P_s) + (1 - \pi)K\mathbf{1}\{P_s \neq R_s\}, \end{aligned} \tag{2}$$

subject to the same budget constraint $C_s + P_s = Z_s$. Following Goldin and Reck (2018), we 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

[8]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 contribution rate.

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, $(1-\beta_s)\delta_s v(P_s)$, is defined as the *welfare internality of savings*. That is the welfare gain of savings that workers do not consider when making saving decisions. One of the potential causes 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) have analyzed the welfare consequences of time inconsistency in the context of retirement saving policies. A more recent paper by Ericson and Laibson (2018) use 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 of 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*. That 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). Additionally, underestimation of the benefit from making an active decision could also be caused by inattention (Caplin and Dean, 2015; Karlan et al., 2016; Gabaix, 2018). In the context of retirement savings, workers may never 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_s and savings $P_s \in \{S_s, R_s\}$, the policymaker will select a default rate r to maximize aggregate normative utility weighted by type-specific Pareto weights α_s:

$$W(r) = \max_{r} \int_{\Sigma(s)} \alpha_s N(C_s, P_s; s, r, K, \pi) dm_s \tag{3}$$

subject to individual optimization

$$\{C_s, P_s\} = \arg\max_{\{\tilde{C}, \tilde{P}\}} U(\tilde{C}, \tilde{P}; s, r, K) \tag{4}$$

where

$$\tilde{C} + \tilde{P} = Z_s.$$

3.2 Optimal Default Contribution Rate

Let r^* denote the optimal default contribution rate. Next we consider the welfare impact 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 $P_s \in \{S_s, R_s\}$. For a continuum of types $s \in [0, 1]$, workers whose preferred saving rates are between s_l and s_h will adhere to the default option where $s_l < d < s_h$. The density of workers saving at the default $m_r = m_l + m_h = \int_{s=s_l}^{d} dm_s + \int_{s=d}^{s_h} dm_s$. We 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. We 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, we introduce the following sufficient statistics:

- ϵ_l: the 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 $\frac{dm_l}{m_r}\frac{1}{dr}$;
- ϵ_h: the 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_s: type-specific social marginal welfare weights. It is 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. As a marginal increase in personal savings could crowd out a given type's eligibility for means-tested social transfers financed by public funds, \$$g_s$ measures that, given the current social transfer system,

the policymaker is indifferent between providing $\$g_s$ to a type-s worker via means-tested social transfers and encouraging her to save an additional dollar. As a result, the type-specific marginal value of savings is inferred by the value of the unspent public funds on means-tested social benefits. The welfare weights can be formally expressed as:

$$g_s := \frac{\alpha_s v'_{P_s}}{\lambda}. \tag{5}$$

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

1. Individuals only make their saving decisions once at the beginning of their working lives.[9]

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_s is linear: $v(P_s) = P_s$.

Next we characterize the optimal default rate r^* based on the policymaker's problem described in Equations (3) - (4). A marginal increase in r^* induces three welfare effects on passive savers whose preferred rates are between s_l and s_h. First, default saving amount of passive savers marginally increase on the intensive margin by $\frac{dN(R_s)}{dr}$. Second, a fraction of h-type passive savers whose preferred rates are above r^* start saving at the increased new default $r^* + dr$, because it is now closer to their preference. This welfare effect on the extensive margin is proportional to $\frac{dm_h}{dr}$, and the savings amount per worker decreases from

[9]Most retirement saving plans allow people to adjust their contribution 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).

$S_h(= s_h Z_h)$ to $R_h(= rZ_h)$. Third, a fraction of l-type passive savers whose preferred rates are below r^* stop saving at the increased new default $r^* + dr$ because it is farther from their preference. This welfare effect on the extensive margin is proportional to $\frac{dm_l}{dr}$, and the savings amount per worker decreases from $R_l(= rZ_l)$ to $S_l(= s_l Z_l)$. The first-order condition for the social welfare function W equals zero at the optimum:[10]

$$\begin{aligned} \frac{dW(r^*)}{dr} &= \frac{d}{dr}\int_{s=s_l}^{s_h} \alpha_s N(P_s) dm_s \\ &\approx \int_{s=s_l}^{s_h} \alpha_s \frac{dN(R_s)}{dr} dm_s + \frac{dm_h}{dr}\alpha_h(N(R_h) - N(S_h)) - \frac{dm_l}{dr}\alpha_l(N(S_l) - N(R_l)) \\ &= 0. \end{aligned} \tag{6}$$

Proposition 1. *Based on Assumptions 1-4, the default contribution 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 A. The overall welfare effect can be decomposed into several terms after the optimal initial default rate marginally increases from r^* to $r^* + dr$:

1. The aggregate weighted social welfare gain to all passive savers on the intensive margin is $\frac{dI}{dr} = \frac{m_l}{m_d} \cdot g_l \cdot (1 - \beta_l)\delta_l Z_l + \frac{m_h}{m_d} \cdot g_h \cdot (1 - \beta_h)\delta_h Z_h$. For example, as the initial default rate increases by dr, 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

[10] We use $N(P_s)$ to represent $N(C_s, P_s; s, r, K, \pi)$ in Equation (3) subject to the budget constraint $C_s + P_s = Z_s$. Pension savings P_s is chosen between the default saving amount $R_s(= rZ)$ and the preferred saving amount $S_s(= sZ)$. The following differentiation under the integral sign employs the Leibniz integral rule where the end points of the interval of the integral s_l and s_h are functions of the derivative argument r.

in the welfare internality of savings for a l-type worker is $(1-\beta_l)\delta_l drZ$, and the marginal increase is weighted by g_l to evaluate its impact on social welfare. The social value of the marginal increase in the welfare internality of savings is then weighted by the fraction of l-type passive savers $\frac{m_l}{m_d} \cdot g_l \cdot (1-\beta_l)\delta_l drZ_l$. Analogously, the social welfare gain to h-type passive savers is $\frac{m_h}{m_d} \cdot g_h \cdot (1-\beta_h)\delta_h drZ_h$. The aggregate weighted social welfare gain on the intensive margin equals $dI = \frac{m_l}{m_d} \cdot g_l \cdot (1-\beta_l)\delta_l drZ_l + \frac{m_h}{m_d} \cdot g_h \cdot (1-\beta_h)\delta_h drZ_h$.

2. The welfare gain to l-type workers for switching to their preferred rate s_l under the new default $r^* + dr$ is $\frac{dS_l}{dr} = |\epsilon_l| g_l (1-\beta_l)\delta_l s_l Z_l$. 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 $\frac{dm_l}{m_r} = dr|\epsilon_l|$. Each l-type worker opting out of the default enjoys the welfare internality of saving at their preferred rate $(1-\beta_l)\delta_l s_l Z_l$ weighted by g_l. The total social welfare gain is $dS_l = dr|\epsilon_l| \cdot g_l \cdot (1-\beta_l)\delta_l s_l Z_l$.

3. The social welfare loss to h-type workers for no longer saving at their preferred rate s_h is $\frac{dS_h}{dr} = |\epsilon_h| g_h (1-\beta_h)\delta_h s_h Z_h$. 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 $(dr|\epsilon_h|)$ no longer enjoy the welfare internality of saving at their preference, $(1-\beta_h)\delta_h s_h Z_h$, weighted by g_h. Similar to the size of dS_l with an opposite direction, the welfare loss to h-type workers for no longer saving at their preference equals $dS_h = dr|\epsilon_h| \cdot g_h \cdot (1-\beta_h)\delta_h s_h Z_h$.

4. The social welfare loss to l-type workers for no is $\frac{dR_l}{dr} \cdot r^* = |\epsilon_l| g_l (1-\beta_l)\delta_l r^* Z_l$. 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 $(1-\beta_l)\delta_l r^* Z_l$ 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 equals $dR_l = dr|\epsilon_l| \cdot g_l \cdot (1-\beta_l)\delta_l Z_l$.

5. The social welfare gain to h-type workers for starting to save at the default rate is

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

6. The social welfare gain to l-type workers for making an active choice is $\frac{dK_l}{dr} = |\epsilon_l| g_l (1-\pi)K$. For each l-type worker on the margin of electing their preferred rate, they enjoy the positive welfare internality of action measured by $(1-\pi)K$. 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 equals $dK_l = dr|\epsilon_l| \cdot g_l \cdot (1-\pi)K$.

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 equals $dK_h = dr|\epsilon_h| \cdot g_h \cdot (1-\pi)K$.

4 Estimating Key Parameters for the Optimal Default Contribution Rate

In this section, we outline an empirical strategy to identify key statistics to be used to estimate the optimal default contribution rate in Proposition 1 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 semi-elasticity of the percentage change in the fraction of l-type passive savers (with preferred rates below the default, denoted dm_l) with respect to the default rate

- ϵ_h: the semi-elasticity of the percentage change in the fraction of h-type passive savers (with preferred rates above the default, denoted dm_h) with respect to the default rate;

- δ_l, δ_h: the normative time preference for l- and h-type passive savers; and

- β_l, β_h: the behavioral time preference for l- and h-type passive savers;

4.1 Semi-elasticities ϵ_l and ϵ_h

The 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 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_d is the fraction of passive savers when the default rate is d.

Based on Equations (7) and (8), we have two strategies to estimate ϵ_l and ϵ_h with their own 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 $\epsilon_h(r) = \epsilon_h$. This empirical assumption can be relaxed when we observe long-term data from OregonSaves.

4.1.1 Identification from Automatic Escalation in OregonSaves

We exploit the exogenous variation in the default rate resulting from automatic escalation to identify the semi-elasticity for l-type passive savers ϵ_l. We 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.

We start by identifying $m_{l'} - m_l$ in Equation (7), which is the change in the fraction of l-type passive savers as the default rate automatically increased from 5% to 6%. Although we do not directly observe the fraction of l-type passive savers under any given default rate, who are passive savers with an underlying preferred rate below the default rate, we can infer the change in the fraction of l-type passive savers from 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 contribution rates for eligible active workers (EAW) eligible for auto-escalation at the end of November 2018 and at the end of June 2019. We exclude EAW eligible for auto-escalation who opted out of the auto-escalation arrangement before it took effect 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 we exclude these is that we 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 contribution 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: $m_{l'} - m_l = -10.6\%$. We 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. We will be able to observe more workers eligible for auto-escalation in the future. We plug in the numbers into Equation (7) and get:

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

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 as it increased by 1 percentage point. Although we can use auto-escalation to identify ϵ_l, we 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. We do not know how they would respond to a default rate other than 5%.

4.1.2 Identification Using Data from Related Literature

We use data from Beshears et al. (2012) to estimate ϵ_h. They studied differential responses to the default rate by income in three employer-sponsored retirement saving plans and they found that the low-paid were more likely to save at the default than the high-paid. Using their data, we 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 contribution 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 contribution 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 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 B provides the distributions of employee contribution rates at Firm C when the default rate was 3% and 5%. Based on Equation (8), we need to 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 increases from 3% to 5%. That is equivalent to a 11% increase in h-type passive savers: $m_{h'} - m_h = 11\%$. We also observe 32% total passive savers under the 3% default rate: $m_r = 32\%$. Plugging these numbers into Equation (8), we get:

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

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. We can also use data from Beshears et al. (2012) to obtain an estimate for ϵ_l:

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

We 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), this firm offers matching up to 7%. As the default rate moves closer to 7% (from 3% to 5%), employees are 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%, we should expect more active savers with matching than without matching. Equivalently, we should expect fewer passive savers with matching than without matching, which makes the observed $m_{h'}$ biased upwards and ultimately makes ϵ_h biased downwards in Equation (10).

4.2 Normative and Behavioral Time Preferences δ and β

The time preference parameters in the optimal default rate formula in Proposition 1 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 following Andreoni and Sprenger (2012).

4.2.1 Estimation Strategy Using Survey Data

Besides the individual-level administrative records of OregonSaves savings data, we surveyed a subgroup of OregonSaves eligible workers in June 2019, including those who opted out and who were participating. We 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 $\beta - \delta$ 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:

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

We used variations in starting times t to identify respondents' behavioral discount rates β. We 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 C 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 was 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 ($= \$100 \times 60$), and the total dollar amount she would have in a year, \$4,000 ($= \$100 \times 40$). The total dollar amount allocated to a sooner time was denoted C and the total dollar amount allocated to a later time was denoted R in Equation (12).

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

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

The parameter α is the CRRA curvature parameter, β 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), we assume that the background consumption level at two time points is the same. When we log-linearize the decision utility function $U(C,R)$, we obtain:

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

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 C; $\mathbf{1}\{t=0\}$ 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. We use a two-limit Tobit maximum likelihood regression to estimate parameters β, δ, and α.

We 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:

$$U(C,R) = -\exp(-\rho C) - \beta\delta^{k}\exp(-\rho R),$$

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

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

4.2.2 Results

Table 9 shows estimates of β 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 β 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 β is 0.993 (s.d.0.007). For a baseline calculation of the optimal default rate, we 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: $\beta_h = 0.987$. The behavioral time preference for l-type passive savers is assumed to be one standard deviation below the average: $\beta_l = 0.982$.

5 Computing the Optimal Default Contribution Rate

The optimal default rate is computed by plugging the values listed in Table 11 into Proposition 1. An additional empirical assumption required to calculate dI, the welfare impact on the intensive margin, is that we 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:

$$\begin{aligned} r^* &= \frac{dI + dS_l - dS_h + dK_l - dK_h}{dR_l - dR_h} \\ &= \frac{2.21 + 2.8 - 6.5 + 39.6 - 38.3}{69.5 - 71.8} \\ &= 8.3\%. \end{aligned}$$

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. We use individual responses to auto-escalation to proxy how two identical groups of workers would respond to two initial default rates differently. 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% baseline calculation should therefore be considered as an upper bound of the optimal default rate.

6 Conclusion

In this paper, we developed a sufficient statistics framework that directly connects empirical analysis of the causal impact of the default contribution rate on individual saving behavior with welfare analysis of the optimal design of the default contribution rate. We introduced a novel set of sufficient statistics to capture low- and mid-income workers' adherence to the default contribution rate based on their perceived liquidity constraints, their concerns on private savings crowding out the eligibility for means-tested social transfers, and their overestimation of the opt-out cost. Given workers' choices on accepting the default contribution rate, we considered the actual interaction between private savings and means-tested welfare programs in a tractable framework for analyzing the welfare impacts of the default contribution rate. We ultimately derived the first explicit formula for the optimal default contribution rate. Using individual-level administrative and survey data from the first state-sponsored auto-enrollment plan in the U.S. called OregonSaves, we empirically estimated key statistics in the formula of the optimal default rate. We found that, when the default rate increased by one percentage point, about an additional of 12% of workers who had passively stayed at the previous default rate would switch to a non-default rate or opt out of the program. Given this insight, a baseline calculation suggested that the optimal default rate should be set at 8%.

Our analysis not only provides direct policy guidance on state-sponsored auto-enrollment plans that expand access for low-income workers, it also lays the groundwork for designing retirement saving policies that take into account the actual social transfer and social insurance systems.

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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 C. 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 discount factor δ	0.995	0.987
	(0.006)	(0.005)
Behavioral discount factor β	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 C, 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

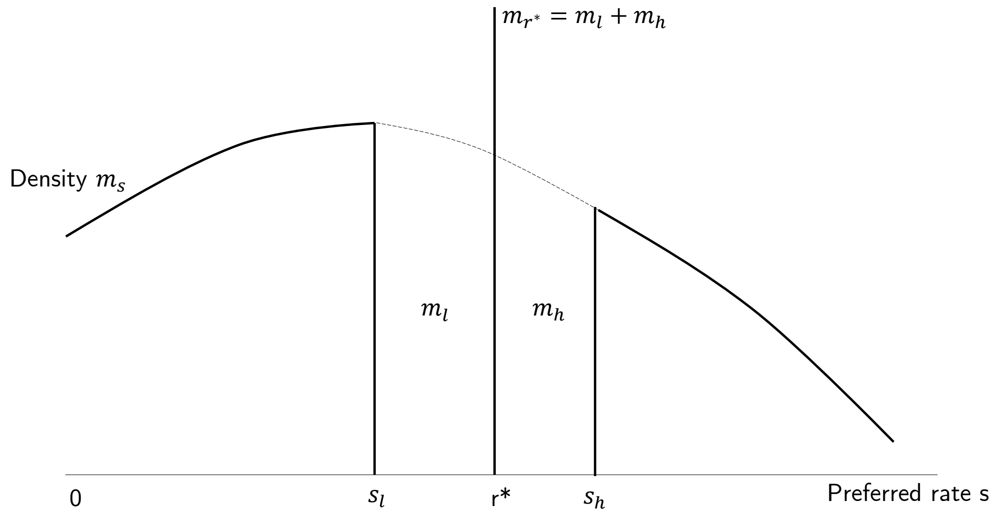
Notes: This table reports estimates of the social marginal welfare weights for l-type passive savers (preferred rates below the default) and for h-type passive savers (preferred rates above the default). The welfare weight for a given type g_s is the Pareto weight α_s normalized by the aggregate weighted 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

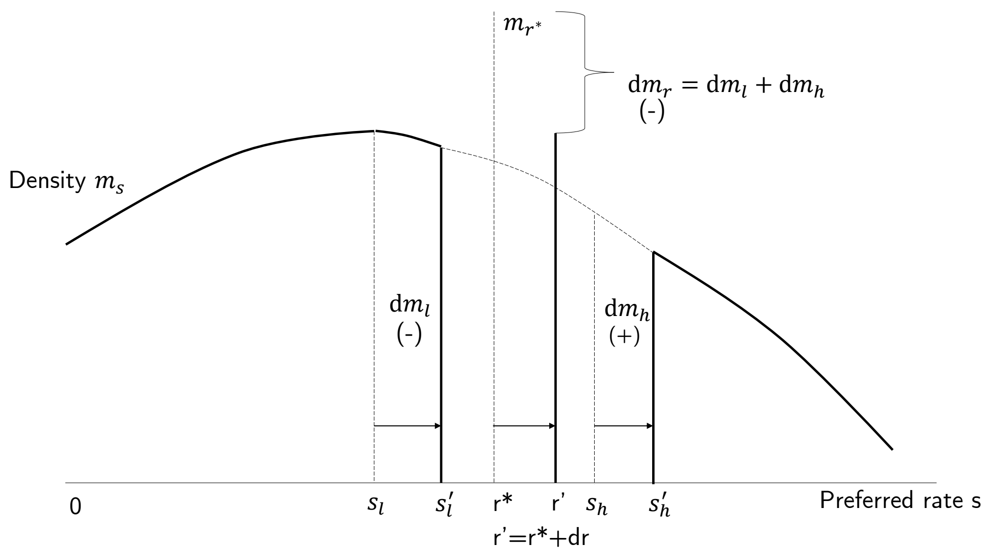
Statistics	Values
Panel A: Statistics for l-type passive savers	
Semi-elasticity ϵ_l	-0.12
Normative time preference δ_l	0.995
Behavioral time preference β_l	0.982
Annual income Z_l	\$24,487
Social marginal welfare weight g_l	1.32
Preferred rate of passive savers on the margin s_l	0.04
Panel B: Statistics 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^*	8.3%

Notes: Estimates of key statistics used to compute the optimal default contribution rate in Proposition 1: 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.

Figure 1: Impact of a Marginal Perturbation of the Optimal Default Contribution Rate r^*



(a) Before a marginal perturbation of r^*



(b) After a marginal perturbation from r^* to $r' = r^* + dr$

Note: See Section 3.2 for details. Solid curves and lines in Figure (a) are the observed density distribution of workers based on their actual contribution rates when the default rate is r^*. Workers with an underlying preferred rate between s_l and s_h are passive savers by accepting the default rate, where the fraction of l-type passive savers is m_l, and the fraction of h-type passive savers is m_h. The observed density at the optimal default is $m_{r*} = m_l + m_h$. Figure (b) shows that, after a marginal increase in the default rate to r', the observed density at the new default rate decreases by dm_r. There are dm_l fraction of l-type passive savers who stop saving at the default because r' is farther from their preferred rate, and dm_h fraction of h-type active savers start to save at the default because it is closer to their preferred rate.

Appendix

A Proof of Proposition 1

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

$$\begin{aligned}\frac{dW(r^*)}{dr} &= \frac{d}{dr}\int_{s=s_l}^{s_h} \alpha_s N(P_s) dm_s \\ &\approx \int_{s=s_l}^{s_h} \alpha_s \frac{dN(R_s)}{dr} dm_s + \frac{dm_h}{dr}\alpha_h(N(R_h) - N(S_h)) - \frac{dm_l}{dr}\alpha_l(N(S_l) - N(R_l)) \\ &= 0.\end{aligned} \tag{15}$$

The first term in Equation (15) can be decomposed into two terms:

$$\begin{aligned}&\int_{s=s_l}^{s_h} \alpha_s \frac{dN_s}{dr} dm_s \\ \approx &\int_{s_l}^{r^*} \alpha_l \frac{dN(R_l)}{dr} dm_l + \int_{r^*}^{s_h} \alpha_h \frac{dN(R_h)}{dr} dm_h \\ = &\,\alpha_l \frac{dN(R_l)}{dr} m_l + \alpha_h \frac{dN(R_h)}{dr} m_h \\ = &\,\alpha_l \frac{dN}{dR_l}\frac{dR_l}{dr} m_l + \alpha_h \frac{dN}{dR_h}\frac{dR_h}{dr} m_h \\ = &\,\alpha_l \frac{dN}{dR_l} Z_l m_l + \alpha_h \frac{dN}{dR_h} Z_h m_h,\end{aligned} \tag{16}$$

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

$$\begin{aligned}\frac{dN}{dR_l} =& \frac{d}{dR_l}(U + (1 - \beta_l)\delta_l v(R_l)) \\ =&(1 - \beta_l)\delta_l v'_{R_l} \\ =&(1 - \beta_l)\delta_l \frac{g_l \lambda}{\alpha_l},\end{aligned} \tag{17}$$

where $g_l := \frac{\alpha_l v'_{R_l}}{\lambda}$ by definition. Similarly, $\frac{dN}{dR_h} = (1-\beta_h)\delta_h \frac{g_h \lambda}{\alpha_h}$. Combining Equations (16) and (17), we rewrite the first term in Equation (15) as:

$$\begin{aligned}
&\int_{s_l}^{s_h} \alpha_s \frac{dN(D_s)}{dr} dm_s \\
=&\alpha_l \frac{\partial N}{\partial R_l} Z_l m_l + \alpha_h \frac{\partial N}{\partial R_h} Z_h m_h \\
=&(1-\beta_l)\delta_l g_l \lambda Z_l m_l + (1-\beta_h)\delta_h g_h \lambda Z_h m_h. \qquad (18)
\end{aligned}$$

Based on Equation (2) that $N(P_s) = U(P_s) + (1-\beta_s)\delta_s v(P_s) + (1-\pi)K\mathbf{1}\{P_s \neq R_s\}$, where $s \in \{h, l\}$ and $P_s \in \{R_s, S_s\}$, the second term in Equation (15) can be rewritten as:

$$\begin{aligned}
&\frac{dm_h}{dr} \alpha_h (N(R_h) - N(S_h)) \\
=&\frac{dm_h}{dr} \alpha_h \Big(U(R_h) + (1-\beta_h)\delta_h v(R_h) - U(S_h) - (1-\beta_h)\delta_h v(S_h) - (1-\pi)K \Big) \\
=&\frac{dm_h}{dr} \alpha_h \Big((1-\beta_h)\delta_h (v(R_h) - v(S_h)) - (1-\pi)K \Big). \qquad (19)
\end{aligned}$$

Workers on the margin of switching to their preferred saving amount $S_h (= s_h Z_h)$ are indifferent from saving at the default or their preference in terms of the decision utility. Therefore, $U(R_h) = U(S_h)$. Based on Assumption (4) that $v(R_h) = R_h$ and the definition of g_h in Section 3.1 that $\alpha_h = \frac{g_h \lambda}{v'_{R_h}} = g_h \lambda$, Equation (19) can be expressed as:

$$\begin{aligned}
&\frac{dm_h}{dr} \alpha_h (N(R_h) - N(S_h)) \\
=&\frac{dm_h}{dr} \alpha_h \Big((1-\beta_h)\delta_h (R_h - S_h) - (1-\pi)K \Big) \\
=&\frac{dm_h}{dr} g_h \lambda \Big((1-\beta_h)\delta_h (r^* - s_h) Z_h - (1-\pi)K \Big). \qquad (20)
\end{aligned}$$

Similarly, the third term in Equation (15) can be expressed as:

$$\begin{aligned}
&\frac{dm_l}{dr}\alpha_l(N(S_l) - N(R_l)) \\
=&\frac{dm_l}{dr}\alpha_l\Big(U(S_l) + (1-\beta_l)\delta_l S_l + (1-\pi_l)K_l - U(R_l) - (1-\beta_l)\delta_l R_l\Big) \\
=&\frac{dm_l}{dr}g_l\lambda\Big((1-\beta_l)\delta_l(s_l - r^*)Z_l + (1-\pi)K\Big).
\end{aligned} \tag{21}$$

Combining Equations (18), (20), and (21), we get

$$\begin{aligned}
\frac{dW(r^*)}{dr} =&(1-\beta_l)\delta_l g_l \lambda Z_l m_l + (1-\beta_h)\delta_h g_h \lambda Z_h m_h \\
&+ \frac{dm_h}{dr}g_h\lambda\Big((1-\beta_h)\delta_h(r^* - s_h)Z_h - (1-\pi)K\Big) \\
&- \frac{dm_l}{dr}g_l\lambda\Big((1-\beta_l)\delta_l(s_l - r^*)Z_l + (1-\pi)K\Big) \\
=&0.
\end{aligned} \tag{22}$$

We rearrange Equation (22) and plug in semi-elasticities $\epsilon_l = \frac{dm_l}{dr}\frac{1}{m_d} < 0$ and $\epsilon_h = \frac{dm_h}{dr}\frac{1}{m_d} > 0$:

$$\begin{aligned}
&\frac{dW(r^*)}{dr} \\
&= (1-\beta_l)\delta_l g_l Z_l m_l - \frac{dm_l}{dr}g_l(1-\beta_l)\delta_l(s_l - r^*)Z_l - \frac{dm_l}{dr}g_l(1-\pi)K \\
&+ (1-\beta_h)\delta_h g_h Z_h m_h + \frac{dm_h}{dr}g_h(1-\beta_h)\delta_h(r^* - s_h)Z_h - \frac{dm_h}{dr}g_h(1-\pi)K \\
&= (1-\beta_l)\delta_l g_l Z_l \frac{m_l}{m_d} + |\epsilon_l|g_l(1-\beta_l)\delta_l(s_l - r^*)Z_l + |\epsilon_l|g_l(1-\pi)K \\
&+ (1-\beta_h)\delta_h g_h Z_h \frac{m_h}{m_d} + |\epsilon_h|g_h(1-\beta_h)\delta_h(r^* - s_h)Z_h - |\epsilon_h|g_h(1-\pi)K \\
&= 0.
\end{aligned}$$

The overall welfare effect can be decomposed into several terms after the optimal initial default rate marginally increases from r^* to $r^* + dr$:

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

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

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

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

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

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^*:

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

B 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%.

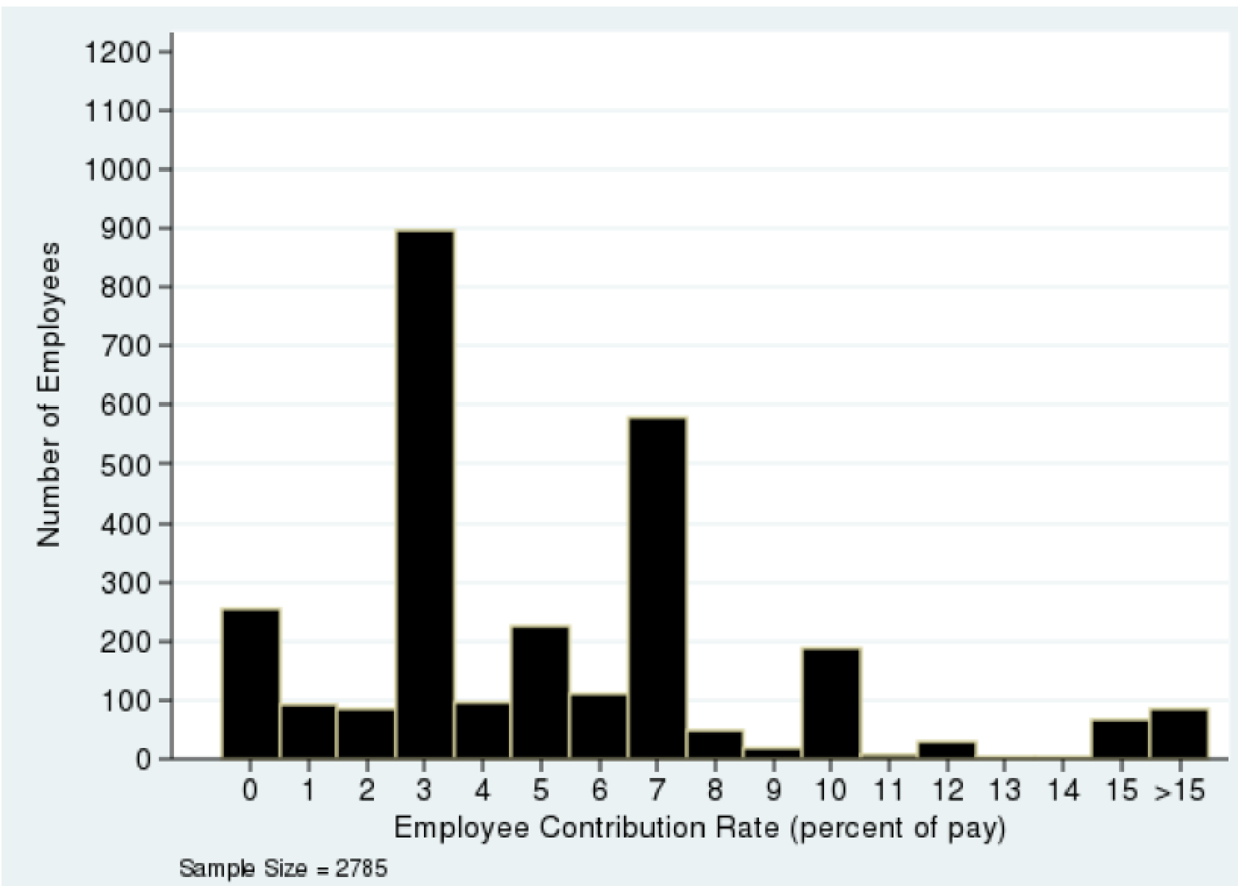
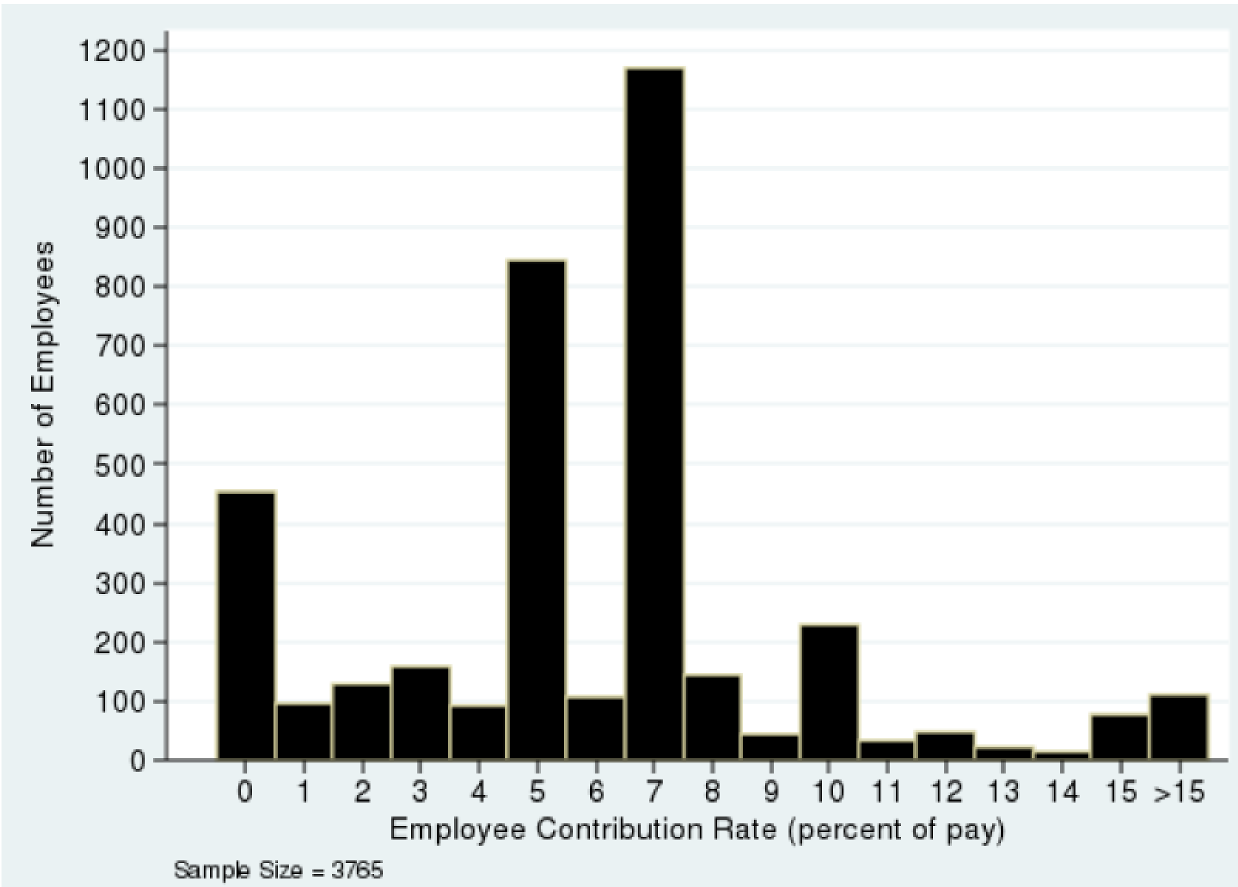


Figure 4. The Distribution of Employee Contribution Rates at Firm C with a 5% Default. This figure gives the distribution of employee contribution rates at one year of tenure at Firm C when there was a 5% default contribution rate. The sample is the 3,765 full-time employees who were hired at the firm 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%.



C Survey Questions to Elicit Time Preferences

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

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.

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: