How Individual Savings Respond to Pension Reform: Implications for Models of Savings Behavior*

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Abstract

How do individual savings respond to pension reform? What are the implications for models of savings behavior? We answer these questions by comparing the behavior observed in detailed administrative data on asset holdings to a life cycle model constructed to quantitatively account for the dynamics of pension benefits and contributions. Exploiting the transition rules across cohorts of a structural reform of the Swedish public pension system, we find that individuals do not respond to the reform: Despite a reduction in future pension income, net wealth and savings rates remain unchanged. The particular setting under study enables an evaluation of competing models of savings behavior. We find that inaction is due to inattention, and not due to inconsistent time preferences in the form of hyperbolic discounting. A model in which 97 percent of individuals are inattentive to the reform can quantitatively account for the lack of response observed in data.

Keywords: Inattention, Pension reform, Present bias, Savings.
JEL classification: E21, G51, and G53.

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1 Introduction

Facing a demographic transition in the form of population ageing, many countries are either making major reforms of their public pension schemes or debating how their new schemes are to be designed and implemented. How do individual savings respond to these pension reforms? The answer is critical for understanding both how well the reforms can solve pension system sustainability problems and how citizens are affected. What are the implications for models of savings behavior? Understanding the drivers of savings and consumption responses to reform is important for at least three reasons: Explaining fundamental household decisions, assessing the impact of reform on individual and aggregate outcomes such as savings and welfare, and ultimately for optimal policy. Yet, there is limited knowledge of how individuals respond to commonly discussed changes in pension system design, such as moving from defined-benefit to defined-contribution plans and from pay-as-you-go to funded financing of pensions. This paper improves the understanding of how, and why, individual savings change after a reform of the Swedish public pension system, with a gradual transition across cohorts from a defined-benefit pay-as-you-go plan to a defined-contribution plan that is partly funded.

Our main contribution is to present a model of savings behavior that can account for the observed inaction to this type of pension reform. Although other studies provide evidence of passive savers, we are unaware of any work that evaluates competing theories of what drives passive choice. For example, in the seminal paper by Chetty et al. (2014), "procrastination" or "lack of information" are listed as potential causes, but no "particular model of passive choice" is specified. Distinguishing between various models is hard because it necessitates an evaluation criterion that is able to choose one potential driver over another. We provide such a criterion in the form of a set of data moments that enable a horse race between competing models. We focus on two models of behavioral bias: One with non-standard preferences in the form of naive present bias (Laibson, 1997), and one with non-standard decision making in the form of inattention (Gabaix, 2014).[1] Thus, our study is—in terms of its contribution and approach—related to the growing literature on behavioral household finance, surveyed in Beshears et al. (2018) and DellaVigna (2018).[2]

The core insight that we use to empirically distinguish between these two theories is to recognize that, while a quantitative model with present bias predicts no response for young individuals, it

[1] See DellaVigna (2009) for a description of "non-standard preferences" and "non-standard decision making".

[2] Other comprehensive surveys on household finance include, for example, Guiso and Sodini (2013) and Gomes et al. (2021).

may still predict responses by older workers that are closer to retirement and that possess higher values of net wealth. In contrast, a model with inattentive agents predicts no response throughout the age distribution. Distinguishing between these theories is important because policymakers that seek to reduce potential costs due to passive behavior need to know about its cause in order to set up an optimal policy. For example, Carroll et al. (2009) show that requiring individuals to make active decisions to enroll in a 401(k) plan is optimal if individuals have a strong propensity to procrastinate but not if individuals have limited financial literacy, when instead a default enrolment is favorable.

The second contribution of our study is to add to a large body of literature that evaluates the degree of crowd-out of pension wealth on private wealth, including the pioneering study by Feldstein (1974). To the best of our knowledge, only Lachowska and Myck (2018) also study savings responses to a *structural* pension reform, in terms of a change in pension system design, as we do in this paper.[3] As they describe, estimates of crowd-out of pension wealth on private wealth are inconclusive across studies, with estimates of degrees of substitution ranging from almost 0 to 0.75. These include pension reforms in the US (Beshears et al., 2022), China (Feng et al., 2011), Italy (Attanasio and Brugiavini, 2003; Bottazzi et al., 2006), the UK (Attanasio and Rohwedder, 2003), Mexico (Aguila, 2011), Poland (Lachowska and Myck, 2018), and Denmark (Chetty et al., 2014). It has been hypothesized that one reason for the wide range of estimates in this literature is that studies differ in the empirical strategies used, but the plausibility of this explanation is questionable because estimates also vary across studies with similar strategies. Since we find that lack of substitution goes hand in hand with inattention, one conclusion from our paper is that differences in results could stem from heterogeneity in salience and complexity of the various reforms used for identification. For example, while both Sweden and Poland changed their public pension schemes from defined benefit to notional defined contribution plans, the Swedish reform included additional changes, e.g. in the degree of funding and the level of guaranteed pension income.

Our analysis builds on a comparison between the behavior observed in detailed administrative data on asset holdings and a structural life cycle model constructed to quantitatively account for pension benefit and contribution rules and changes therein. Our first result is that the Swedish pension reform had significant implications for future pension income and pension wealth. By simulating labor income based on processes estimated from data, we measure the implied changes in pension income due to the reform, and find that the median loss in expected future annual pension income

[3] See e.g. French et al. (2022) and Laun and Palme (2022) for studies on how labor supply respond to structural pension reforms.

of the first transition cohort born in 1938 is -7 percent. This cohort was in their late fifties when the reform was decided in parliament in the mid-1990s, leaving not much time to respond before retiring. Under the assumption that individuals retire at age 65, the median drop in present value pension wealth for this cohort amounts to -15 percent of the private wealth possessed in the beginning of 1996. In a standard model with rational and forward-looking individuals, this implies increased savings of the cohorts affected. However, our second result shows that such a response is absent in data. Both in terms of private net wealth and active savings rates, the affected cohorts are not adjusting their behavior. Even when the affected cohorts have entered retirement, almost a decade after the decision to implement the reform, we observe no effects on private wealth or savings rates.

What are the implications for models of savings behavior? To compare models, we choose moments in data which, when related to the same moments in simulated data from the quantitative model, are informative about the drivers of savings responses to pension reform. Importantly, this comparison is enabled by the particular setting and consequences of the Swedish reform. First, since the reform leads to reduced future pension income for most affected individuals it incentivizes an increase in savings before entering retirement. As described by Ganong and Noel (2019), failing to respond to an expected fall in future income can not be explained by liquidity constraints since it should induce individuals to save *more*. Instead, other explanations such as adjusting labor supply before retiring or failing to respond due to behavioral bias must be key reasons for inaction along the savings margin. Second, we can observe treated individuals both before and after entering retirement. If individuals respond to the reform by increasing labor supply, they also increase labor income. Since the additional labor income is partly saved, individuals end up with more wealth in retirement. Thus, the absence of changes in wealth and savings rates during retirement also rejects any significant response in terms of labor supply, and we therefore consider models of behavioral bias. Third, since the oldest individuals experiencing reform are in their late fifties at the announcement of the reform, changes in future pension income translate into large shifts in pension wealth because retirement is not an event happening far away into the future. This rules out present bias as an explanation for the lack of savings responses. On the one hand, present bias makes agents respond less to negative future income shocks because of temptation to not cut down on current consumption. On the other hand, present bias makes agents hold less net wealth and increases the marginal propensity to consume out of a negative shock to future income, both because more individuals are closer to the liquidity constraint and because the marginal propensity to consume is greater at the constraint (Laibson et al., 2021). Since the individuals that we study are close to retirement, the first effect i smaller than the second effect, implying that present bias does not improve the model's ability to account for inaction.

We find that a model of inattention reconciles model predictions with data. Inspired by Campbell and Mankiw (1989) and Gabaix (2014), we propose a model in which attentive agents are informed about the pension system and solve a problem in which all aspects of the pension system, including the reform, are taken into account. Inattentive agents instead resort to heuristics. They form a prior belief that future pension income is determined by a simple rule, which in our case is formulated such that income during retirement is given by a share of earnings in the period prior to retirement. For this reason, inattentive agents do not take changes in the pension system into account when making their decisions, and instead solve a sparse problem with fewer state variables. We estimate that 97 percent of individuals are inattentive to the pension reform, resulting in a reform effect that is in line with the data. While the model does not take a stand on why individuals are inattentive, studies by Cronqvist and Thaler (2004) and Lindqvist et al. (2018) provide evidence of pervasive reporting about the reform in the media at the time of its implementation. This suggests that individuals were informed about the fact that the reform was taking place, but that they were unable to foresee its effects, potentially due to low levels of financial literacy (Lusardi and Mitchell, 2014) or pension knowledge (Mitchell, 1988; Elinder et al., 2020).

The remainder of the paper is organized as follows. Section 2 describes the pension reform, Section 3 shows how individual savings respond to the reform, with the prediction of the standard model in subsection 3.1 and the results from our empirical analysis in subsection 3.2. Section 4 describes the behavioral biases under consideration and the results from our model evaluation, and Section 5 concludes.

2 The Swedish pension reform

This section describes the reform of the Swedish public pension system. For the purpose of our analysis, we focus on the pensions of private sector workers who constitute about 70 percent of Swedish workers.

Sweden is currently implementing a reform of its public pension system, with the main objective of improving the financial sustainability of the system. The new pension system was introduced in 1999 after a number of decisions by parliament in the mid 1990s, and the first pension pay-outs from the new system took place in 2001. However, due to the gradual phasing-in of the reform, the new system will not be fully implemented until around 2050.

The reform introduces a funded scheme alongside the PAYGO scheme, it constitutes a shift from a defined benefit system to a defined contribution system, and it makes the PAYGO scheme more actuarial, whereas the increased minimum guaranteed pensions imply a less actuarial system. The reform thus consists of movements along all three dimensions of pension system classification as described by Lindbeck and Persson (2003). The taxonomy of pension systems by Lindbeck and Persson (2003) is presented in Appendix A.1. The reform contains several common elements to proposed changes in pension systems elsewhere, as in e.g. the US (Mitchell and Zeldes, 1996; Shiller, 2006; Geanakoplos and Zeldes, 2009), .

Old public system

In the old public system, the defined benefit consists of two parts: a basic allowance (*folkpension*) and an income dependent supplement (*ATP*). The basic allowance is the same for everyone and equal to 96 percent[4] of a base amount.[5] The income dependent supplement depends on the individual's 15 highest income-years during working life. For each of these years, pension points are computed by taking income in excess of one base amount up to 7.5 base amounts and dividing this by one base amount.[6] The average pension points over the 15 years are then used to compute the individual's pension benefit from the income dependent supplement in the formula:

$$Supplement_{i,t} = 0.60 \times AveragePoints_i \times BaseAmount_t \tag{1}$$

[4]This is if the individual is unmarried; for married individuals, the basic allowance is 78.5 percent of a base amount.

[5]Base amounts are used to compute benefits and contributions in the Swedish social insurance system. They are determined annually by the government to reflect and adjust for inflation. In 2022, the base amount is 48,300 SEK ($\approx 4,830$ USD) and the income-related base amount, which adjusts for income growth, is 71,000 SEK ($\approx 7,100$ USD).

[6]The maximum annual pension points are thus 6.5.

Individuals with no income dependent supplement are granted a special supplement (independent of marital status) of 55.5 percent of a base amount, which is reduced on a one-to-one basis against the income dependent supplement.

New public system

In the new public system, the defined contribution is 18.5 percent of the working-age individual's income, up to an income ceiling of 7.5 (income-related) base amounts. 16 percentage points of this go to the PAYGO scheme (*inkomstpension*) and 2.5 percentage points go to the individual's funded account (*PPM*). The individual's contributions to the PAYGO scheme translate into pension rights. The value of an individual's accumulated pension rights increases with indexation from one year to the next, and with new contributions from the current year. The index used is an income index that reflects the average wage growth. The PAYGO scheme is thus a notional defined contribution (NDC) scheme, in which the notional return is determined by an income index, whereas pension benefits are, in fact, financed by current contributions.[7] The return to the individual's funded account is determined by the return to the funds chosen by the individual. Pension benefits are then paid out in the form of annuities.

There is gradual phase-in of the new public pension system. For the PAYGO scheme, individuals born in 1937 or earlier are completely in the old system, whereas individuals born in 1954 or later are completely in the new system. Individuals born in 1938-1953 are in both systems: Those born in 1938 obtain 16/20 of their entitled benefits under the old system and 4/20 of their entitled benefits under the new system, those born in 1939 obtain 15/20 from the old system and 5/20 from the new system etcetera. All individuals start to pay contributions to the funded scheme at the same time, in 1999. To compensate older cohorts that are in the new system for not being able to contribute to the funded scheme prior to 1999, they receive additional benefits through the new PAYGO scheme. Individuals in transition cohorts therefore receive benefits from the PAYGO scheme as if they had made additional contributions of 2.5 percentage points of annual earnings over the full course of their working life prior to 1999. The use of national buffer funds, originally accumulated to support the financial sustainability of the old public system, facilitates the transition between the two systems.[8]

[7] The fact that the return reflects the growth in the average wage rather than the growth in the total wage bill introduces financial unsustainability in the system: If current contributions to the system are unable to meet a return in line with the income index, the pension authority chooses another index by which they compute the value of accumulated pension rights.

[8] According to Hagen (2013), in 1998, the amount in the buffer funds was equal to approximately 5 years' worth of

Minimum guaranteed pensions

In 2001, a minimum guaranteed pension was introduced in place of the basic allowance and the special supplement in the old system. The minimum guaranteed pension tops up public pensions to at least 2.3 base amounts if the individual is unmarried, or at least 1.9 base amounts if the individual is married. It is means-tested against the earnings-related pension from the PAYGO scheme, similarly to how the means-tested special supplement worked in the old system. However, if individuals get an occupational pension, this does not affect the minimum guaranteed pension.

Occupational pensions

More than 90 percent of Swedish workers are covered by occupational pension schemes, which are part of the collective agreements made between employers and labor unions. There are two large occupational pension schemes in the private sector, one for blue-collar and one for white-collar workers. The occupational pension schemes have undergone reforms in the same direction as the public pension system, although the timing and affected cohorts differ. For the purpose of our analysis, we focus on the reform of the public pension system and model occupational pensions in line with applicable rules, see Appendix A.2 for details.

benefits, a substantial amount. In 2013, there was around 4 years' worth of benefits. However, projections from the early 1990s showed that with unchanged contribution rates, the buffer funds would be exhausted sometime between 2010 and 2015; a major motivation for the reform.

3 How individual savings respond to pension reform

3.1 Prediction of the standard model

We depart from a standard life-cycle overlapping generations model of a small open economy.

Model set-up

There are three types of agents in the model: Individuals that are either private sector blue-collar ($\tau = BC$) or white-collar ($\tau = WC$) workers and a pension provider that manages the public and occupational pension schemes. Individuals enter the model at age 25, indexed to $h = 1$. They die with certainty at age H and retire at age H_{ret}. The conditional probability of surviving between ages h and $h+1$ for an individual born in year j is $\phi_{h+1,j} \in [0,1]$ and hence, the unconditional probability of surviving until age $h+1$ is $\Phi_{h+1,j} = \prod_{k=1}^{h} \phi_{k,j}$. Markets are incomplete in the sense that, except for the pension assets described below, individuals only invest in a risk-free and liquid asset with rate of return r, and individuals face a borrowing constraint which creates a motive for precautionary savings. Labor income is exogenous and, since the economy is open, the interest rate is also exogenous. The economy starts in a steady state with constant demographics and the old pension system ($s = \mathcal{O}$). During the transition, the population ages and the pension reform ($s = \mathcal{R}$) takes place by gradually phasing in new rules across cohorts. Finally, the economy reaches a new steady state with constant demographics and the new pension system ($s = \mathcal{N}$) fully in place.

Throughout the paper, individuals are indexed by i, birth cohorts by j, ages by h, worker types by τ, and pension systems by s. However, subscripts are occasionally suppressed to simplify notation.

Labor income. We assume that the process of gross labor income is identical across cohorts j. Since pension systems alter labor income only through their effects on disposable labor income net of pension contributions and taxes, subscript s is dropped below.

Gross labor income $Y_{i,h}^{\tau}$ for individual i of age $h \in [1, H_{ret}]$ and type τ has a permanent component $P_{i,h}^{\tau}$ and a transitory component $E_{i,h}$:

$$Y_{i,h}^{\tau} = P_{i,h}^{\tau} E_{i,h} \tag{2}$$

which follow the laws of motion:

$$\log E_{i,h} = \varepsilon_{i,h} \tag{3}$$

$$\log P_{i,h+1}^{\tau} = \log D_{h+1}^{\tau} + \rho_P \log P_{i,h}^{\tau} + \eta_{i,h+1} \tag{4}$$

where D_h^τ is a deterministic age-component that is common for all individuals of the same type and that captures the hump-shaped life-cycle profile of income, and $\varepsilon_{i,h}$ and $\eta_{i,h}$ are shocks such that $e^{\varepsilon_{i,h}}$ and $e^{\eta_{i,h}}$ are independently and identically lognormally distributed with $E[e^{\varepsilon_{i,h}}] = E[e^{\eta_{i,h}}] = 1$:

$$e^{\varepsilon_{i,h}} \sim \ln N(-\sigma_\varepsilon^2/2, \sigma_\varepsilon^2) \tag{5}$$

$$e^{\eta_{i,h}} \sim \ln N(-\sigma_\eta^2/2, \sigma_\eta^2). \tag{6}$$

Preferences. Individuals maximize their current and future expected utility from consumption by adopting an optimal savings plan. Instant utility takes the form of a CRRA utility function with a constant intertemporal elasticity of substitution equal to $1/\gamma$:

$$U(C) = \begin{cases} \frac{C^{1-\gamma}}{1-\gamma} & \text{if } \gamma > 0 \text{ and } \gamma \neq 1 \\ \log C & \text{if } \gamma = 1 \end{cases} \tag{7}$$

where C denotes consumption.

In addition to deriving utility from contemporaneous consumption, individuals have a warm-glow bequest motive as in De Nardi (2004):

$$U^b(B) = \nu_1 \frac{(B + \nu_2)^{1-\gamma}}{1-\gamma} \tag{8}$$

where B denotes the wealth that is left as bequests in the case of death, ν_1 governs the importance of bequests in relation to consumption, and ν_2 governs the extent to which bequests are a luxury. In our application of the model, the bequest motive serves as a way to limit the extent of decumulation of private wealth at older ages, as observed in the data. In principle this could be achieved by alternative assumptions, such as by including long-term-care expenses (Ameriks et al., 2020). In Appendix B.5, we show that our main results still hold when using a model without bequests.

Individual problem. To simplify notation, subscripts i, j and τ are dropped below. An individual of age $h \in [1, H]$ who pays contributions and receives pension benefits according to pension system

$s \in \{\mathcal{O}, \mathcal{N}, \mathcal{R}\}$ solves:

$$\begin{aligned} V_h^s(P_h, A_{h-1}, \Psi_h^s) = & \\ & \max_{C_h, A_h} U(C_h) + \delta \times \mathbb{E}\left[\phi_{h+1} V_{h+1}^s(P_{h+1}, A_h, \Psi_{h+1}^s) + (1-\phi_{h+1}) U^b(B_{h+1})\right] \quad (9) \\ & \text{s.t.} \quad A_h + C_h = (1+r)A_{h-1} + Y_h^{s,net} \quad (10) \\ & \quad B_{h+1} = (1+r)A_h \quad (11) \\ & \quad A_h \geq 0, \quad A_0 = 0 \quad (12) \\ & \quad \Psi_{h+1}^s = F^s(\Psi_h^s) \quad (13) \end{aligned}$$

where P_h is the permanent income component, A_h denotes a risk-free and liquid asset with rate of return r, and Ψ_h^s is a set of state variables that captures the pension system s. Individuals discount future expected utility using exponential discount factor δ, and $Y_h^{s,net}$ denotes disposable labor and pension income (net of pension contributions and taxes). For simplicity, we assume that bequests are collected and spent outside the model, and hence not transferred to the young in the form of private wealth.

In the pre-reform system, the set of state variables Ψ^s consists of a set of two additional state variables. For transition cohorts, it consists of four and three additional state variables for blue-collar and white-collar workers, respectively. This implies that there can be up to eight exogenous state variables relevant for the individual's decision. To solve the problem, we use a version of the endogenous grid point method (Carroll, 2006) proposed by Almerud and Österling (2017) that first simulates paths of the stochastic processes of exogenous states before solving the model, and then uses nearest-neighbor interpolation to find the most representative path. In addition, determining the values of these state variables is not trivial since it involves computing annuities of non-linear functions of future labor income. See Appendix B for details on the solution method as well as computations of disposable income and state variables.

Pension provider. The pension provider manages the public and occupational pension schemes. In the pre-reform pension system, the pension provider balances the public and occupational defined benefit schemes by solving for the contribution rates, to ensure that payments into the system equal payments out of the system. The pension provider balances the occupational schemes within occupational groups, so that blue-collar (white-collar) workers fund occupational pensions for blue-collar (white-collar) retirees. In the post-reform pension system, the contribution rate to the public NDC scheme is exogenous, as are the contribution rates to the public and occupational funded schemes.[9] The pension provider solves for the tax rate needed to fund the minimum guaranteed pension. The balanced budget conditions for the pre and post-reform pension systems are defined in Appendix B.3.

Model experiment

In 1996, agents are informed about the gradual phasing-in of the new pension system across cohorts.[10] We consider income and savings dynamics during a transition between an initial scenario and a future scenario with demographic developments and the pension reform. The results from this transition are compared to the results from a transition between the initial scenario and a future counterfactual scenario without the pension reform. Specifically, the economy starts out in 1975 with constant mortality and fertility rates. In 1976, agents understand that the mortality and fertility rates will fall over time. From 2050 and onwards, the fertility and mortality rates for different ages are again constant at their new lower levels.

During the transition from the old to the new public pension system, individuals born in year j get a share $1-\omega_j \in [0,1]$ of their public pension income determined according to the rules in the old system (Y^{pub}) and a share ω_j of their public pension income determined according to the rules in the new system, where $\underline{Y}^N$ denotes the minimum guaranteed pension, Y^p is the pension income from the NDC scheme, and Y^f is the pension income from the funded scheme (PPM), See Section 2. Hence, an individual born in year j receives the following pension income from the public system:

$$(1-\omega_j)Y^{pub} + \omega_j \max\{\underline{Y}^N, Y^p\} + Y^f. \tag{14}$$

The cohorts affected by the reform of the public pension system are born in 1938 and later, see Section 2.

Budget balancing during the transition. Surpluses or deficits can occur in the NDC scheme since the value of accumulated pension rights is computed using an index that reflects the average wage growth (rather than the growth in the total wage bill). In reality, national buffer funds can be used to cushion temporary differences between pension contributions and pension benefits. Since

[9] In the public NDC scheme, the task of the pension provider is instead to choose the index by which to compute the value of accumulated pension rights. The index used typically reflects average wage growth, but the pension provider may have to use a different index to balance the budget, see Section 2.

[10] Specifically, the phasing-in of the new occupational scheme for blue-collar workers starts in 1996, the phasing-in of the new public scheme starts in 2000, and the new occupational scheme for white-collar workers is implemented in 2007, see Section 2.

we do not model the buffer fund, we allow for a temporary deficit in the new pension system during the transition. In our baseline calibration, there is indeed a deficit of about 3.5 percent of total gross income at the outset of the reform in 2000. This deficit then gradually diminishes and, in the long run, there is instead a surplus of about 10 percent of total gross income.

Model calibration

Demographics. The starting year of our analysis is 1975. The initial birth rate is calibrated to match the Swedish old-age dependency ratio (ODR) in 1975. The final birth rate is calibrated to match the projected Swedish ODR in 2075 (OECD, 2021). The birth rates of cohorts entering the labor market during the demographic transition are given by a linearly spaced interpolation between the initial birth rate of 0.7 percent and the final birth rate of 0.5 percent. In the model, the mortality probability between ages h and $h+1$ for an individual born in year j is $(1-\phi_{h+1,j}) \in [0,1]$. Exogenous mortality probabilities (actual and projected) are obtained from Statistics Sweden.

Labor income. The deterministic age-dependent part of the permanent income component, D_h^τ, is obtained from Laun and Wallenius (2015). Our deterministic income profiles for blue-collar and white-collar workers are averages of the two profiles for each worker category in Laun and Wallenius (2015). Incomes are expressed in base amounts as described in Section 2. Labor income shock processes for Swedish individuals are obtained from Domeij and Flodén (2010). These shock processes are based on individuals with a strong attachment to the labor market earning at least the equivalent of half the effective minimum wage each year.

Other parameters. The elasticity of intertemporal substitution are set to standard values in the literature. The interest rate r can be seen as an after-tax composite real rate of return on the portfolio of household assets. It is calibrated to 2 percent, reflecting the current low interest rate environment and the fact that Swedish households hold a substantial part of their private savings in bank accounts yielding low nominal returns. The rate of return on notional pension wealth in the new public scheme, g, is also set to 2 percent, reflecting the average real wage growth in Sweden. All pension system parameters are chosen in line with the description in Section 2, with income ceilings and incomes expressed in base amounts. The share of white-collar workers in the labor force, $1-\chi$, is calibrated to 43 percent, reflecting the share of 25-64 year-olds with a college education in Sweden in 2018. A summary of exogenous parameters is given in Table 1.

Table 1: Exogenous parameters.

Parameter	**Description**	**Value**
H_0	Age when individuals enter the model	25
H	Maximum years alive after age H_0	75
H_{ret}	Years until retirement at age H_0	40
σ_η^2	Variance of persistent earnings shock	0.0169
σ_ε^2	Variance of idiosyncratic earnings shock	0.0584
$1/\gamma$	Elasticity of intertemporal substitution	1/2
r	Interest rate	0.02
g	Rate of return on NDC pension wealth, new public scheme	0.02
$\overline{Y}$	Income ceiling for contributions & repl. rates	7.5
m	No. of highest income-years, old public scheme	15
ρ	Repl. rate on average pension points, old public scheme	0.60
ρ^{BC}	Repl. rate on average pension points, old blue-collar scheme	0.10
ρ_1^{WC}	Repl. rate on income up to $\overline{Y}$, old white-collar scheme	0.1
ρ_2^{WC}	Repl. rate on income between $\overline{Y}$ and $\overline{Y}_2^{WC}$, old white-collar scheme	0.65
ρ_3^{WC}	Repl. rate on income between $\overline{Y}_2^{WC}$ and $\overline{Y}_3^{WC}$, old white-collar scheme	0.325
λ^{itpk}	Contr. rate, old funded white-collar scheme	0.02
$\overline{Y}_2^{WC}$	Second income ceiling for repl. rates	20
$\overline{Y}_3^{WC}$	Third income ceiling for repl. rates	30
λ^p	Contr. rate, new public NDC scheme	0.16
λ^f	Contr. rate on income up to $\overline{Y}$, new funded system (public + occ.)	0.07
$\overline{\lambda}^f$	Contr. rate on income above $\overline{Y}$, new funded system (occ.)	0.30
$\underline{Y}^O$	Basic allowance, old public system	0.96
$\underline{Y}^N$	Guaranteed minimum pension, new public system	2
$1-\chi$	Share of white-collar workers	0.43

Note: These parameters are either taken from the literature or chosen to match the Swedish pension system.

Discounting and bequests. With the parameter values above, we calibrate discounting and bequest parameters by matching moments of wealth from data. The exponential discount factor, δ, is chosen to match total private net wealth as a share of total disposable income of individuals of age 63–65. The importance of bequests relative to consumption, ν_1, is chosen to match median private net wealth of 80 year-olds divided by median private net wealth of 65 year-olds, and the extent to which bequests are a luxury, ν_2, is chosen to match the 90th percentile of private net wealth divided by median private net wealth of 68–76 year-olds. These moments are inspired from the calibration in Karlman et al. (2021).

Table 2: Wealth moments to match.

Description	**Value**
Total A of 63–65 year-olds / Total Y of 63–65 year-olds	4.07 (0.48)
Median A of 80 year-olds / Median A of 65 year-olds	0.92 (0.04)
90th percentile A / Median A of 68–76 year-olds	4.99 (0.14)

Note: A denotes net wealth and Y denotes gross labor income. Each moment is given by its average across years 2000–2007. Numbers in parentheses denote the standard errors of the time series during the same period.

Table 3: Calibrated parameters.

Parameter	**Description**	**Value**
δ	Exponential discount factor	0.96
ν_1	Importance of bequests relative to consumption	31.26
ν_2	Luxury good parameter for bequests	13.13

Note: These parameters are calibrated by matching simulated data from the model to the moments in Table 7.

Model results

In this section, we present results from the model experiment described above, i.e. where outcomes for transition cohorts are compared to corresponding outcomes in a counterfactual scenario without pension reform.

Pension income. The new pension system results in lower replacement rates of working-age incomes which creates an increased incentive to accumulate savings for retirement. Furthermore, when the reform occurs late in life, lower contribution rates do not, on average, compensate for the drop in pension income during retirement. Hence, the reform does, on average, have a negative net effect on total life-time income.

To gauge the size of the loss due to the reform, we compute the change in present value pension wealth as given by the difference in discounted future pension income of individuals born in a given year $\bar{j}$ of age $\bar{h} < H_{ret}$. Pension wealth PW^s in pension system s is given by:

$$PW^s = \sum_{k=H_{ret}}^{H} \delta^{k-\bar{h}} \left(\prod_{l=\bar{h}+1}^{k} \phi_{l,\bar{j}} \right) \mathbb{E}_{\bar{h}} \left[Y^s_{k,\bar{j}} \right] \tag{15}$$

and the wealth loss L is given by:

$$L = \frac{PW^{\mathcal{R}} - PW^{\mathcal{T}}}{A_{\bar{h}-1,\bar{j}}} \tag{16}$$

where $PW^{\mathcal{R}}$ denotes pension wealth in the case of a pension reform and $PW^{\mathcal{T}}$ denotes pension wealth in the counterfactual case of no pension reform but only a demographic transition. Since individuals respond to changes in pension wealth by adjusting private wealth, we relate the change in pension wealth to the amount of private wealth prior to the announcement of the reform. We focus on the first transition cohort born in 1938 in the year of reform announcement, 1996, when this cohort is of age 58.

Table 4 shows the percentage change in expected pension income and pension wealth across the distribution of blue-collar and white-collar workers, respectively. When the cohort born in 1938 receives information about the reform, most individuals expect to receive lower pension income when entering retirement. The median annual pension income losses amount to -6.1 and -8.0 percent, respectively, and losses are heterogeneously distributed across the population, resulting in an interquartile range of 4.7 percentage points for blue-collar workers and 2.9 percentage points for white-collar workers. Due to greater progressivity in the reformed pension system, white-collar workers, with greater incomes on average, are more negatively affected. In fact, about 9 percent of blue-collar workers expect to get a higher pension income in the reformed system.

Table 4: Changes in pension income and pension wealth for cohort 1938 in the announcement year of the reform in 1996.

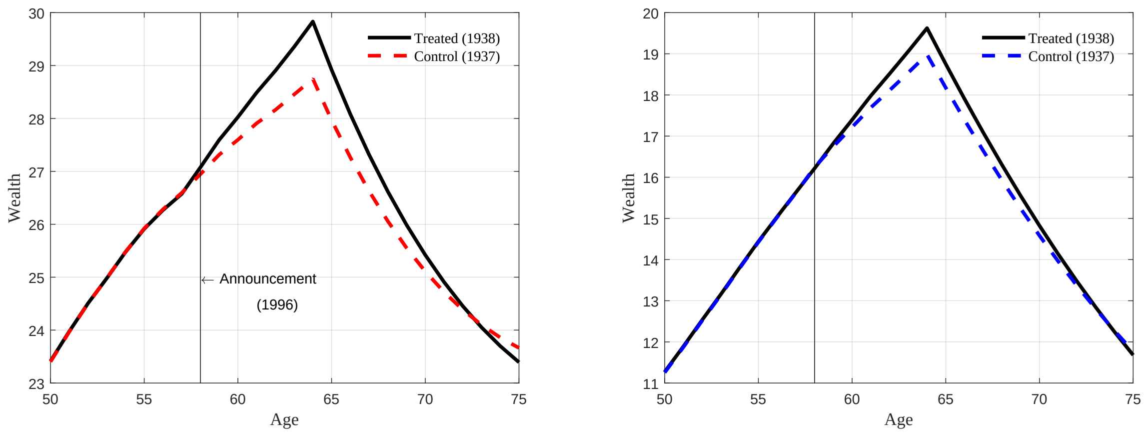
	Change in pension income (%)		**Pension wealth loss (%)**	
Percentile	Blue-collar	White-collar	Blue-collar	White-collar
25th	−7.9	−9.0	−19.2	−33.8
50th	−6.1	−8.0	−13.4	−19.8
75th	−3.2	−6.1	−8.2	−11.7

Note: *Change in pension income* shows the difference between annual pension income in the old system and the reformed system expressed as a share of annual pension income in the old pension system. *Pension wealth loss* shows the pension wealth loss due to the reform as a share of private wealth prior to the announcement year, i.e. in 1995.

The two rightmost columns of Table 4 show that reduced pension incomes due to the reform imply substantial losses in pension wealth throughout the distribution. Since cohort 1938 is 58 years old at the time of announcement of the reform, they expect to collect pension benefits for a large share of their remaining lives. As we shall see below, this incentivizes them to save more before entering retirement.[11]

Savings. Figure 1 shows that the cohort born in 1938 accumulates more private wealth during working life compared to the cohort born in 1937. This increase in wealth accumulation is a response to the reform announcement in 1996 when the cohort born in 1938 is 58 years old.

Figure 1: Private net wealth in ages 50–75 for cohort 1938 (solid lines) and cohort 1937 (dashed lines) for white-collar workers (left panel) and blue-collar workers (right panel).

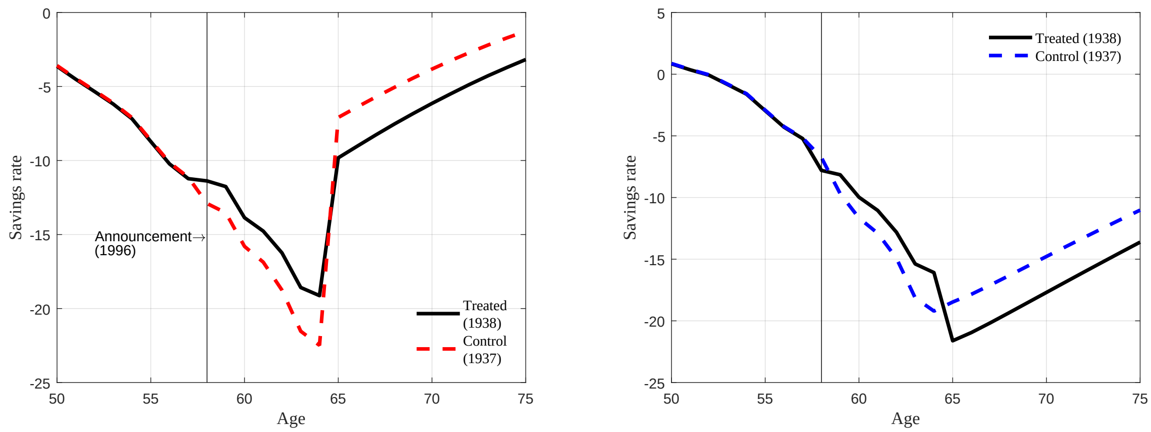


Note: Units on vertical axis are in income base amounts. The vertical line at age 58 shows the age of the cohort born in 1938 at the year of announcement of the reform.

The pattern in Figure 1 is reflected in Figure 2, which depicts the corresponding savings rates. In response to the reform announcement at age 58, the cohort born in 1938 has a higher savings rate (decumulates less wealth) prior to retiring at age 65, compared to the cohort born in 1937. The additional stock of private wealth is then consumed during retirement, reflected in a lower savings rate from age 65 for the cohort born in 1938, compared to the cohort born in 1937.

[11] We have cross-checked the implied change in pension wealth with the results in Kolsrud et al. (2021). We get an average loss of about $-105,000$ SEK and they find a loss of approximately $-100,000$ SEK). Although there are some differences in how to compute this loss, we conclude that the results are fairly similar.

Figure 2: Savings rate in ages 50–75 for cohort 1938 (solid lines) and cohort 1937 (dashed lines) for white-collar workers (left panel) and blue-collar workers (right panel).



Note: Units on vertical axis are in percentage points. The vertical line at age 58 shows the age of the cohort born in 1938 at the year of announcement of the reform.

Figure 2 also shows that the model produces highly negative savings rates during the ages around retirement. This is a result from the calibration to the data moments in Table 2, which yields large levels of net wealth compared to labor and pension income in combination with relatively low bequest motives become stronger only in older ages when conditional survival probabilities falls rapidly. In the data, the level of both net wealth and savings rates appear to be highly affected by time effects. In particular, as shown in Appendix C.3, average savings rates swings from about −10 percent in year 2004 to 10 percent in 2006 for the cohorts we study. Since the model is not constructed to capture such time effects, we do not calibrate it directly to savings rates measured in the data.

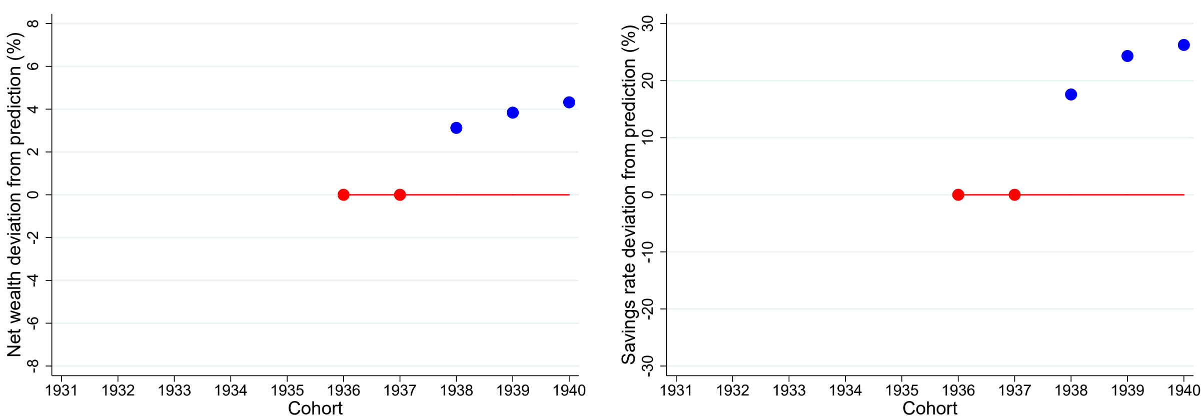
Model results comparable to data. Our final goal is to relate the results from our model to our empirical findings. We therefore also present results from our model that can be easily related to results from our empirical investigation in Section 3.2. In anticipation of the empirical exercise laid out in detail there, Figures 3 and 4 show model outcomes for simulated data of wealth and savings rates across cohorts in 2000 and 2007, respectively. To facilitate comparison of outcomes from the model to those in actual data, average net wealth and savings rates are expressed in terms of deviations from their predicted levels using unaffected cohorts born before 1938. In 2000, cohorts born in 1936–1940 are working-age, whereas in 2007, cohorts born in 1931–1940 are retired.[12] It is important to look at working-age and retired individuals separately since the motive

[12]These year-cohort combinations are chosen to align with our data window, see Section 3.2.

for accumulating and decumulating wealth changes considerably at the the time of retiring, partly because of changes in retirement savings, but also because of changes in precautionary savings. Based on outcomes for cohorts unaffected by the reform, we make a linear prediction for affected cohorts and see that cohorts affected by the reform save more during working-age and dis-save more during retirement, compared to the prediction based on unaffected cohorts. We also see that this difference is more pronounced for younger transition cohorts, in line with our expectation.

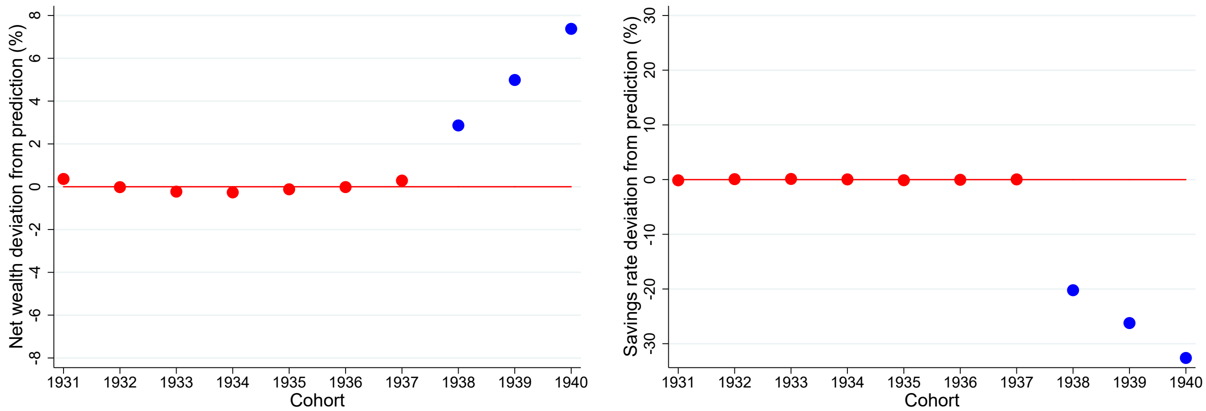
In 2000, when the cohorts studied are still working, affected cohorts hold about 3–5 percent more net wealth than expected from the linear prediction, and have more than 15–25 percent higher active savings rates. After retirement, in year 2007, affected cohorts still hold more net wealth of approximately 3–8 percent above the prediction. However, savings rates are then lower than predicted, amounting up to −30 percent lower than predicted. Since affected cohorts accumulate more net wealth before retiring, and then receive lower pension incomes during retirement, the savings rates turn out to be lower than predicted due to more decumulation of wealth during retirement.

Figure 3: Net wealth (left panel) and savings rates (right panel) in 2000 for unaffected cohorts (red) and affected cohorts (blue).



Note: Values are scaled by the prediction (the fitted regression line.) Thus, the red regression line is flat at 0. Values on the vertical axis are in terms of percent deviation from the prediction. The size of the confidence interval is a function of the number of observations simulated. Hence, confidence intervals are not included.

Figure 4: Net wealth (left panel) and savings rates (right panel) in 2007 for unaffected cohorts (red) and affected cohorts (blue).



Note: Values are scaled by the prediction (the fitted regression line.) Thus, the red regression line is flat at 0. Values on the vertical axis are in terms of percent deviation from the prediction. The size of the confidence interval depends on the number of observations simulated. Hence, confidence intervals are not included.

3.2 Empirical analysis

Administrative data

The basis of our empirical analysis is administrative data on asset holdings at the individual level covering all taxpayers in Sweden. Prior to 2007, the Swedish tax authority collected detailed information on taxpayers' holdings of financial and real estate assets due to the presence of wealth and real estate taxes. Between 2000 and 2007, this data was delivered to Statistics Sweden and has been made available for research. Moreover, we use administrative data on incomes, municipality of residence, and moves within Sweden. The unique social security number of each Swedish individual allows Statistics Sweden to combine these data sources. See Appendix C.1 for additional information on the administrative data used. Our main results are for a restricted sample of individuals, see Appendix C.2 for details.

Wealth and savings measures

We combine administrative data on asset holdings and income with data on asset returns to create measures of net wealth, savings flows and savings rates. This allows us to obtain an almost complete picture of an individual's net wealth and active savings. All variables are measured annually at the individual level. In the formulas below, the subscripts for individual, cohort, and age (i, j, and h) is dropped for brevity.

Net wealth. Our measure of net wealth in year t is given by:

$$w_t = -d_t + b_t + v_t + \mathbb{H}_t + \psi_t \tag{17}$$

where d_t denotes debt, b_t denotes bank account holdings, v_t denotes holdings of mutual funds, stocks, and bonds, $\mathbb{H}_t$ denotes housing, and ψ_t denotes asset holdings in so called capital insurance accounts. We do not observe asset holdings in so called private pension accounts, which for most individuals is a minor item. We observe our measure of net wealth between 2000 and 2007.

Savings flow. The flow of savings should reflect active decisions to rebalance wealth. Hence, it should not reflect changes in wealth due to unrealized capital gains. Therefore, we compute the savings flow as the difference between the actual stock of assets and the estimated stock of assets under the assumption of no rebalancing, following Koijen et al. (2015) and Bach et al. (2017, 2020). The estimated stock of assets of type x in time t under the assumption of no rebalancing is given by the stock in time $t-1$, x_{t-1}, multiplied by the gross return between time $t-1$ and time t: $(1 + r_t^x) = R_t^x$. Hence, the savings flow for assets of type x is $\Delta x_t = x_t - x_{t-1}R_t^x$. The flow of savings f_t is thus given by:

$$f_t = -\Delta d_t + \Delta b_t + \Delta v_t + \Delta \psi_t + \omega_t \tag{18}$$

where $\Delta d_t = d_t - d_{t-1}$ denotes changes in debt, $\Delta b_t = b_t - b_{t-1}R_t^b$ denotes rebalancing of bank account holdings, $\Delta v_t = v_t - v_{t-1}R_t^v$ denotes rebalancing of mutual funds, stocks and bonds, and $\Delta\psi_t = \psi_t - \psi_{t-1}R_t^\psi$ denotes rebalancing of holdings in capital insurance accounts. For private pension accounts, we observe the net contribution ω_t. Since we need the lags of the wealth variables, we are able to compute savings flows between 2001 and 2007.

For bank account holdings, the return is given by the average deposit rate considering all bank account holdings obtained from Statistics Sweden. For mutual funds, stocks and bonds, we compute the individual-specific portfolio return excluding any distributions (dividends or coupons). Data on the returns on individual mutual funds and stocks are obtained from DataStream, MoneyMate or FINBAS (the database of the Swedish House of Finance). When the return on a mutual fund or a stock is missing, we impute it using the MSCI World Index returns. For capital insurance accounts, holdings of individual securities are unobserved. Therefore, we use the cum-dividend return on the all-share Stockholm Stock Exchange as a proxy for the return on capital insurance accounts. For changes in debt, interest payments are not considered since they do not add to the stock of debt.

Note that compared to the measure of net wealth above, rebalancing of housing $\Delta\mathbb{H}_t = \mathbb{H}_t - \mathbb{H}_{t-1}R_t^{\mathbb{H}}$ is excluded from the savings flow measure. Rebalancing of housing, $\Delta\mathbb{H}_t$, differs from 0 only if an individual transacts or invests in housing. However, we do not observe actual transaction prices of property and cannot distinguish changes in value due to investment from changes in value due to changing market conditions. Therefore, we exclude individuals that are likely to transact property based on that they a) change their official address and b) experience a large change in property values (for all remaining individuals, $\Delta\mathbb{H}_t$ is set to 0). See Appendix C.2 for details.

Savings rate. The savings rate sr_t is given by the savings flow, f_t, in relation to total disposable income:[13]

$$sr_t = \frac{f_t}{y_t + k_t} \tag{19}$$

where y_t denotes disposable labor and pension income (see Appendix B.1 for details), and k_t denotes capital income.[14] Since we need the lags of the wealth variables, we are able to compute savings rates between 2001 and 2007.

Empirical strategy

The fact that the data time frame only allows for computing net wealth for 2000–2007 and savings flows and savings rates for 2001–2007 puts limitations the empirical strategy. In our setting, the degree of reform treatment is determined by birth cohort. An estimate of the reform effect that relies on direct comparison of treated and non-treated cohorts in a given year is thus potentially biased by age-cohort effects. In principle, this could be overcome by using a difference-in-differences strategy. Given that the parallel trends assumption holds prior to the announcement year, any difference in trends between treated and non-treated cohorts from announcement and onwards is an unbiased estimate of the reform effect. However, such a strategy is not possible in our setting since we do not have data prior to 2000, whereas the reform was discussed in parliament during the mid 1990s and introduced in 1999.

In light of these issues, we do not estimate the reform effect from data. Instead, we take a structural approach in the spirit of the structural behavioral estimation literature surveyed in DellaVigna (2018) to test competing models of savings responses to pension reform by applying the method of simulated moments (McFadden, 1989; Lee and Ingram, 1991; Duffie and Singleton, 1993) as

[13] Our savings rate measure corresponds to the "net" savings rate in Fagereng et al. (2021).

[14] Capital income on mandatory funded savings (such as mandatory pension savings) is not included in disposable income since individuals cannot freely dispose of this income.

described in Section 4. When we have a model that can account for the empirical moments used, we then provide a reform effect by analyzing counterfactuals in the model, described in detail in Section 3.1.

The simulated method of moments approach entails two main challenges. First, it is necessary to define moments that are, to the greatest extent possible, determined by responses to the pension reform and not by responses to simultaneous (expected or unexpected) structural shocks. In our setting, the simultaneous shocks which may affect savings that first come to mind are those driven by age, cohort, or time effects, e.g. due to time-varying asset prices. We overcome this challenge by choosing moments in data which, when related to the same moments in simulated data, are jointly informative about the drivers of savings responses to pension reform. In particular, differences in private net wealth and active savings rates between affected and unaffected cohorts prior to and after retirement represent such moments conditional on filtering out age, cohort, or time effects from the data. Time series of average wealth stocks and savings flows of different cohorts indicates that the lion's share of variation comes from time effects (see Figure 14 in Appendix C.3). We therefore control for time effects by fixing the year when defining our moments. We then estimate the age-cohort effect by regressing the outcome variable of interest on birth cohorts in the given year. By only including cohorts that belong to the old pension system, the regression provides a prediction of the age-cohort effect on the outcome variable for treated cohorts, and excludes the reform effect. Thus, the difference between actual outcomes of savings and estimated age-cohort effects in a given year provides a moment that overcomes the challenge of simultaneous structural shocks.

Second, the moments used for identification must be useful for distinguishing between different models of savings behavior. For example, a moment is useful if it can only be rationalized by one out of several different models. It turns out that the particular transition rules and the timing of implementation of the Swedish pension reform enables such a horse race between competing models. Since the treated cohorts are in their late fifties at the announcement of the reform, changes in future pension income translates into large shifts in pension wealth because retirement is not an event happening far away into the future. This rules out inconsistent time preferences as a possible explanation for the lack of savings responses because the degree of temptation must be implausibly large. Finally, a comparison of the joint set of the stock of private wealth and savings rates both prior to and after retirement proves to be fruitful because it rules out other extensions of our standard model. For example, postponing retirement due to the reform makes the model worse off in terms of wealth and savings rates after retirement, which rules out endogenous labor supply as a potential explanation for the model's inability to account for what is observed in the data.

Empirical moments. We mimic the procedure used for Figures 3 and 4: For a given year t, we estimate the age-cohort effect for net wealth and savings rate using cohorts born before 1938 that are unaffected by the reform. This as an age-cohort effect since, conditional on being in year t, the change between cohorts can be due to cohorts being of different ages in year t, or that they were born in different years, or both. We then use this age-cohort effect to make a prediction for cohorts born in 1938 or later that are affected by the reform. The difference between this prediction and actual measures from data is our prediction error, which we compare to our model outcomes. Formally, this procedure is given by:

1. For a given year t, regress net wealth or savings rate $y = \{w, sr\}$ on non-treated cohorts $j < 1938$:

$$y_{i,j} = \beta_0 + \beta_1 j + u_{i,j}.$$

2. Make prediction for treated cohorts $j \geq 1938$:

$$\hat{y}_{i,j} = \hat{\beta}_0 + \hat{\beta}_1 j.$$

3. Compare the prediction error, as given by a distance measure $d_{i,j}$ between prediction $\hat{y}_{i,j}$ and actual values $y_{i,j}$, for treated cohorts $j \geq 1938$ in data with model simulation.

In step 1., we cluster on cohorts using cluster-robust standard errors, except for in the year 2000 when the prediction is only based on two non-treated cohorts. In step 3., we use a distance measure given by the prediction error in percent of the predicted value, formally defined as $d_{i,j} \equiv 100 \times \text{sgn}(\widehat{y}_{i,j}) \times \frac{y_{i,j} - \widehat{y}_{i,j}}{\widehat{y}_{i,j}}$. The second term, equal to 1 if $\hat{y}_{ij} \geq 0$ and to -1 if $\hat{y}_{ij} < 0$, is needed to give the correct sign of the prediction errors, since predicted and actual values of savings rates can be both positive and negative.

In the next section, we provide a graphical illustration of the average prediction errors. It is important to stress again that we do not interpret prediction errors as a causal effect of the pension reform, since it is not possible to observe the affected and unaffected cohorts both before and after the announcement of the reform. Instead, the prediction errors serve as moments that can distinguish between competing models of responses to pension reform, by a comparison to the same moments from simulated data generated by different models. This is an important reason for why our model outcomes endogenously respond to not only pension reform but also age-cohort effects that could lead to systematic differences in prediction errors across cohorts. Our model includes such age-cohort effects via age-specific or cohort-specific labor income profiles, birth rates, survival probabilities, and contributions to the pension system.

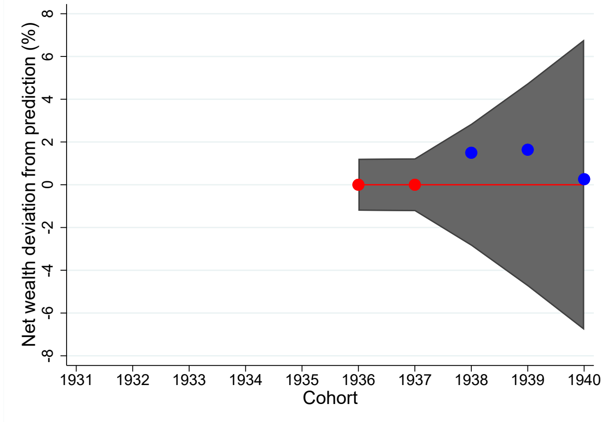
Empirical results

In this section, we show how the results from applying our empirical strategy on administrative data. As described in the section above, the graphical representation provided here serves as suggestive evidence of inaction to the pension reform, while the comparison between actual and simulated data in Section 4.1 below serves as a rigorous examination of the implications on models of savings behavior.

As described in above, we focus on working-age and retired individuals separately. In 2000, cohorts born in 1936–1940 are working-age, whereas in 2005 and 2006, cohorts born in 1931–1938 and 1931–1939 are retired.We do not report results for the year 2007 since there were tax reforms aimed at increasing the labor supply of individuals over the age of 65 implemented in that year, which delayed retirement in this group, see Laun (2017). There were also other policy changes implemented in 2007 aimed at increasing labor supply more generally, which can be expected to affect cohorts closer to the age of 65 to a larger extent.

The figures below show actual values for cohorts affected by the reform in blue compared to predicted values based on unaffected cohorts in red. The grey areas are 95 percent confidence intervals of the predicted values, computed using the standard errors of the fitted values. Figure 5 shows that cohorts affected by the reform do not accumulate more wealth compared to cohorts unaffected by the reform. In fact, the net wealth of affected cohorts line up well with the predictions for this measures based on the behavior by unaffected cohorts. The alignment of affected and unaffected cohorts indicates an unresponsiveness of net wealth to the pension reform four years post-announcement of the reform.

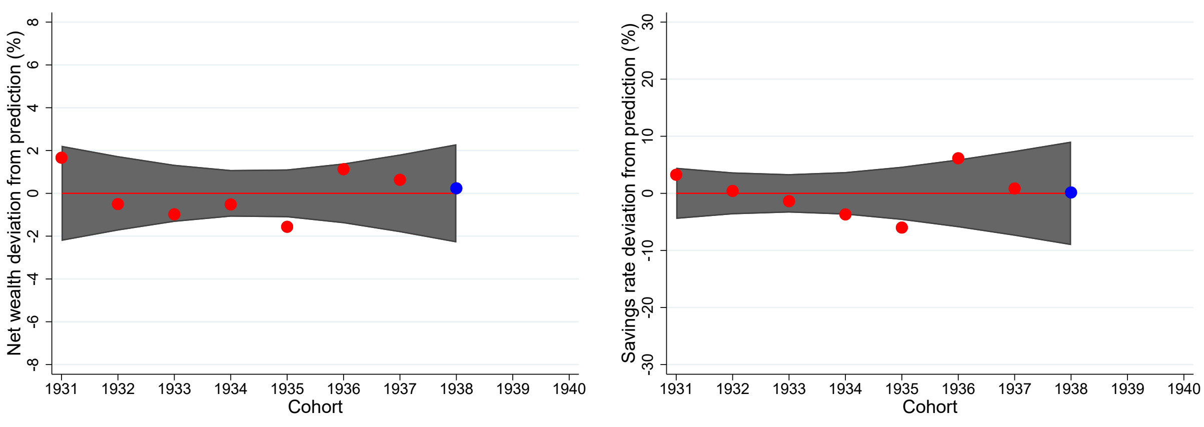
Figure 5: Net wealth in 2000: Working-age cohorts.



Note: Values are scaled by the prediction (the fitted regression line.) Thus, the red regression line is flat at 0. Values on the vertical axis are in terms of percent deviation from the prediction. The gray area shows the 95% confidence interval.

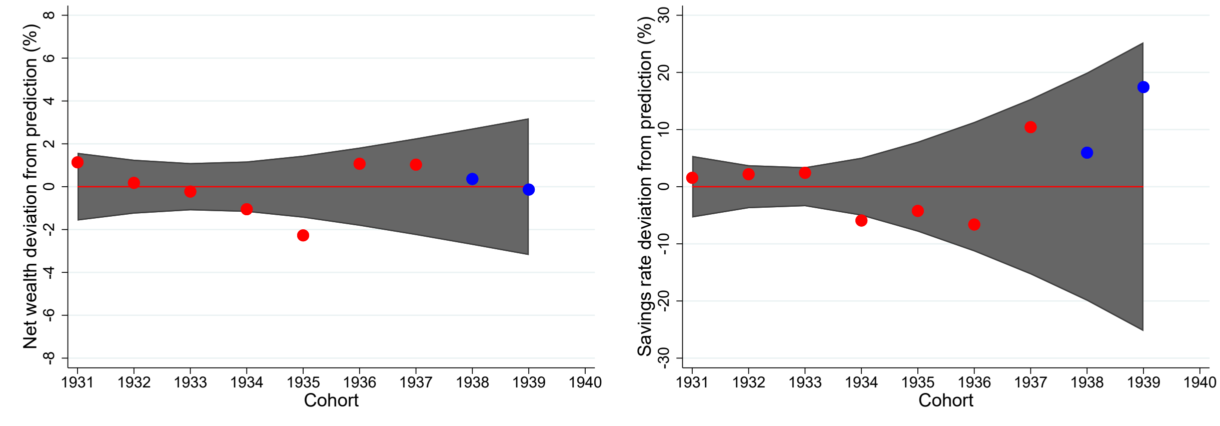
The same picture emerges for later years in Figures 6 and 7. In 2005 and 2006, nine and ten years post-announcement of the reform, respectively, the net wealth of affected cohorts is still in line with the prediction based on the behavior of unaffected cohorts.

Figure 6: Net wealth (left panel) and savings rates (right panel) in 2005: Retired cohorts.



Note: Values are scaled by the prediction (the fitted regression line.) Thus, the red regression line is flat at 0. Values on the vertical axis are in terms of percent deviation from the prediction. The gray area shows the 95% confidence interval, clustered on cohorts.

Figure 7: Net wealth (left panel) and savings rates (right panel) in 2006: Retired cohorts.



Note: Values are scaled by the prediction (the fitted regression line.) Thus, the red regression line is flat at 0. Values on the vertical axis are in terms of percent deviation from the prediction. The gray area shows the 95% confidence interval, clustered on cohorts.

From this analysis, we conclude that the standard model does not capture the inaction to pension reform observed in the data. The next section explores how the standard model should be augmented in order to be able to account for such inaction.

4 Implications for models of savings behavior

4.1 Behavioral biases

To account for the unresponsiveness of savings to pension reform, we suggest a model augmented with behavioral bias. Our framework proves to be well suited to distinguish between various biases proposed in the literature, and we therefore analyze two separate extensions of the standard model respectively. First, a natural candidate for aligning model predicitions with the data is to assume present bias, poineered by Strotz (1955) and Laibson (1997). The reason for is simple: If the future is heavily discounted, individuals decide to not respond to future income shocks because of temptation to be better off today. Second, a competing explanation would be that unresponsiveness is driven by inattention to the reform. We follow Gabaix (2014) by solving a sparse problem in which individuals resort to heuristics. Instead of taking all details of the pension system and its reform into account, individuals make retirement savings decisions based on a simple rule of thumb.

Naive present bias

For simplicity, we consider the case when individuals are naive about their present bias, as in e.g. Laibson et al. (2021). Although individuals correctly understand that they discount the future more heavily today, they falsely believe that they will not be present biased in the future. This assumption makes the individual problem easier to solve since it precludes a dynamic game between temporal selves.

Individual problem with naive present bias. An individual with naive present bias solves

$$\begin{aligned} W_h^s(P_h, A_{h-1}, \Psi_h^s) = & \\ \max_{C_h, A_h} \quad & U(C_h) + \beta\delta \times \mathbb{E}\left[\phi_{h+1} V_{h+1}^s(P_{h+1}, A_h, \Psi_{h+1}^s) + (1-\phi_{h+1}) U^b(B_{h+1})\right] \\ \text{s.t.} \quad & \text{equations (10)–(13)} \end{aligned} \tag{20}$$

where V_h^s is the value function with time-consistent preferences, given by (9). This problem admits quasi-hyperbolic discounting with short-run discount factor $\beta\delta$ and long-run discount factor δ. Individuals are naive about their present bias since they falsely believe that their future selves are exponential discounters.

Inattention

To model inattentiveness to the pension reform, we set up a sparse dynamic problem in the spirit of Gabaix (2014, 2017).[15] The problem is sparse since it ignores the state space relevant for the pension system, Ψ_h^s, and hence excludes the law of motion (13). Instead of observing state space Ψ_h^s, individuals follow a rule of thumb by assuming that pension income will equal a share μ of permanent income in the period prior to entering retirement, $Y_h^{net} = \mu P_{H_{ret}-1}^{net}\ \forall h \geq H_{ret}$. When entering retirement, this belief turns out to be incorrect since pension income is indeed determined as a function of Ψ_h^s. In our baseline specification, we let $\mu = 0.85$ for all individuals.

Individual problem with inattention. An individual that does not take the pension system into account when making their decision solves

$$\begin{aligned} &\tilde{V}_h(P_h, A_{h-1}) = \\ &\qquad \max_{C_h, A_h} \quad U(C_h) + \delta \times \mathbb{E}\left[\phi_{h+1}\tilde{V}_{h+1}(P_{h+1}, A_h) + (1-\phi_{h+1})U^b(B_{h+1})\right] \\ &\qquad \text{s.t.} \quad \text{equations (10)–(12)} \end{aligned} \tag{21}$$

The sparse problem can also be solved for individuals with present bias by changing the value function on the LHS of (21) to $\tilde{W}_h(P_h, A_{h-1})$ and the short-run discount factor on the RHS to $\beta\delta$.

Estimation. We use the method of simulated moments to estimate the parameters that pin down time preferences, the bequest motive, and the share of inattentive agents.

As in Section 3, the exponential discount factor, δ, the value of the importance of bequests relative to consumption, ν_1, and the value that determines the extent to which bequests are luxuries, ν_2, are estimated for each model specification. Hence the moments in Table 2 are also targeted in the matching exercise done here. Parameters of present bias, β, and inattention, α, are estimated once in a model that nests each one of them, respectively. In all model specifications, we also include the average of relative distances, $\bar{d}_j$, of prediction errors in wealth and savings rates for cohort $j \in [1938, 1940]$ from our empirical analysis of the reform.

We use years when both the control group (cohorts born before 1938) and the treatment group (born after 1937) are simultaneously either 64 years or younger, or 67 years or older. In addition,

[15] Using the notation in Gabaix (2014), individuals are exposed to a sufficiently large cost κ such that they pay no attention ($m = 0$) to states relevant for the pension system, and instead use a heuristic approach to form a belief about future pension income.

the control group must consist of at least two cohorts in any given year. For the data window that we have, including years 2000-2007, the implied years and cohorts used for estimation are shown in Table 5.

Table 5: Ages of cohorts at the given years.

	Controls			**Treated**		
Year	1935	1936	1937	1938	1939	1940
2000		64	63	62	61	60
2005	70	69	68	67		
2006	71	70	69	68	67	

Using these years and cohorts results in 9 additional moments (6 for wealth, and 3 for savings rates), as given by Table 6. The table shows the average prediction errors in data, expressed in percent of the predicted values. Absolute prediction errors are lower in data than in simulated data from the standard model. For example, in year 2000, the standard model gives prediction errors of net wealth of 3–4.5% as compared to 0.3–1.6% in the data.

Table 6: Prediction distance moments to match, in percent.

	Wealth			**Savings rates**		
	Cohort			Cohort		
Year	1938	1939	1940	1938	1939	1940
2000	1.5	1.6	0.3			
	(1.5)	(2.5)	(3.5)			
2005	0.2			0.2		
	(0.9)			(3.7)		
2006	0.4	-0.1		6.0	17.4	
	(1.1)	(1.3)		(8.2)	(10.3)	

Note: Parentheses denote standard errors when clustering on cohorts, except for net wealth in year 2000 when standard errors are not clustered.

To evaluate competing models, we find estimates $\hat{\theta}$ that minimize the goodness of fit

$$GOF(\theta) = e(\theta)'We(\theta)$$

where the error of the k^{th} moment is given by the percent deviation between the simulated data moment (m_k^{sim}) and the corresponding moment from actual data (m_k): $e_k(\theta) = 100 \times \frac{m_k^{sim}(\theta) - m_k}{m_k}$, and W is a weighting matrix. The optimal weighting matrix is the variance-covariance matrix of the moment condition errors $e(\theta)$, which can be estimated by applying an iterative fixed point method that minimizes $GOF(\theta)$. However, completing only one iteration process is computationally burdensome simply because the structural model must be solved at each step of the iteration. For this reason, we let W be the inverse of a diagonal matrix with values equal to the implied variances of the standard errors reported in Tables 2 and 6.

Table 7: Model estimates.

	Present bias	**Inattention**
Naive hyperbolic discount factor (β)	1.00	
Share of inattentive agents (α)		0.97
		(0.00)
Number of moments	12	12
Number of free parameters	1	1
Goodness of fit	3.13×10^7	3.32×10^6

Note: The table reports free parameters and not parameters that are fixed by assumption. In all model simulations we set $\delta = 0.96$, $\nu_1 = 31.26$, and $\nu_2 = 13.13$, as in the calibration of the baseline model. The goodness of fit of the baseline model is then 3.13×10^7. In all entries with no reported number, $\beta = 1$ and $\alpha = 0$ by assumption. Parentheses report standard errors. Standard errors are not reported when the estimate is at the boundary. Weighting matrix is equal to the inverse of a diagonal matrix with a diagonal equal to the variances implied by the reported standard errors. Inattentive agents expect to get the share $\mu = 0.70$ of permanent income in the last working age ($P^{net}_{H_{ret}-1}$) as retirement income.

Table 7 shows that the baseline model augmented with present bias is not able to account for the unresponsiveness to pension reform. However, the baseline model augmented with inattention provides a substantial improvement in goodness of fit, given that almost all individuals are inattentive to the reform. The inattention share of 97 percent is on par with the result in Chetty et al. (2014) that the share of passive savers is at least 85 percent. While the estimation in Table 7 is based on an assumption of fixed parameter values $\delta = 0.96$, $\nu_1 = 31.26$, and $\nu_2 = 13.13$, we provide a robustness check in Appendix B.5 where all four parameters are free. Also then, the share of inattentive agents is very high, with an estimated value of 96 percent.

5 Conclusion

This study proposes that a model of inattention accounts for the inaction in savings responses to pension reform observed in the data. Thanks to the particular setting and consequences of the Swedish pension reform under study, we are able to reject competing models of inaction. We focus explicitly on another source of behavioral bias in the form of naive present bias. Although one could think of other reasons causing inaction, most of them are not plausible in our context. For example, while liquidity constraints could explain why individuals fail to save less, it can not explain why they fail to save more, which is the case in our setting. Also, the fall in expected future income should induce individuals to work more, either by increasing their intensive labor supply or their extensive labor supply by prolonging retirement. Both of these adjustments would lead to higher net wealth prior to retirement, but this is not observed in the data. Laun and Palme (2022) find limited effects of the pension reform on labor supply.

One additional reason that have the potential to account for inaction in our setting, which we did not analyze in this paper, is the fact that individuals face a less restrictive time budget during retirement (Aguiar and Hurst, 2005; Rogerson and Wallenius, 2013, 2016, 2018). This is an additional margin through which negative shocks to retirement income can be smoothed. However, several studies point to that the importance of this channel is limited (Aguila et al., 2011; Been et al., 2020, 2021), partly because only 11% of market consumption is substitutable to home production, and the elasticity of substitution between home production and substitutable consumption is -0.65. We conclude that home production has the potential to account for inaction qualitatively, but leave it to future studies to analyze whether it can do so quantitatively.

Given our finding that inattention can quantitatively account for inaction, a natural next question is *why* individuals are inattentive to the reform. Although our paper does not confront this question, other studies, such as Cronqvist and Thaler (2004), Cronqvist et al. (2018), and Lindqvist et al. (2018), show that there was ample information about the reform in the media at the time. Thus, it is not plausible that inattentiveness arised due to not knowing about the reform. Instead, it should be because of limited understanding of the reform's impact, which could be due to financial illiteracy (Lusardi and Mitchell, 2014) or little knowledge about the pension systems (Elinder et al., 2020). Thus, our main result motivates more research along these dimensions.

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Appendix

A Pension system

We here provide a classification of various pension systems as in the taxonomy by Lindbeck and Persson (2003), and additional information about the Swedish pension system.

A.1 Taxonomy of pension systems

Lindbeck and Persson (2003) classify pension systems in three dimensions: PAYGO versus funded, defined benefit versus defined contribution and non-actuarial versus actuarial. A pension reform can be described as a movement along one or more of these dimensions.

In a PAYGO or *unfunded* system, pension benefits are financed by contributions from currently working generations. In a *funded* system, by contrast, an individual's pension benefits are financed by the accumulated pension contributions made by the individual during their working life. An individual may receive higher returns to their contributions to a funded system than the implicit return to contributions to a PAYGO system, which consists of growth in the total wage bill.

In a *defined benefit* PAYGO system, the pension benefit is either a fixed amount or an amount determined by the individual's previous earnings. This implies that the contribution rates for the working generations have to be endogenous for the pension budget to balance. In a *defined contribution* PAYGO or funded system, by contrast, the contribution rate is exogenous while the benefits are endogenous. A defined benefit system distributes risk differently among generations, within generations, and over an individual's life-cycle, compared to a defined contribution system.

In a *non-actuarial* PAYGO system, an individual's pension benefit is unrelated to the individual's pension contributions. One example would be a pension system in which all retired individuals receive equal shares of the current aggregate contributions, regardless of their past individual contributions to the system. In an *actuarial* system, by contrast, there is a strong relationship between contributions and benefits at the individual level. Shifting from a non-actuarial to an actuarial system typically increases the work incentives and has effects on labor supply.

One concern with defined benefit PAYGO systems and ageing populations is that the endogenous contribution rates may have to increase to very high levels for the pension budgets to balance. Without such an increase the systems would become financially unsustainable. This does not apply to defined contribution PAYGO and funded systems, in which benefits are determined by contributions.

A.2 Occupational pension schemes

Occupational pensions for blue-collar workers

Private sector blue-collar workers typically work in manufacturing, construction, hotels and restaurants, or retail and are covered by the occupational pension scheme for blue-collar workers. In the pre-reform scheme (*STP*), the pension benefit depends on the individual's three highest income-years between the ages of 55 and 59. For each of these years, pension points are computed by taking income in excess of one base amount up to 7.5 base amounts and dividing by one base amount. The average pension points over the three years are then used to compute the individual's pension benefit in the formula:

$$Occupational_{i,t} = 0.10 \times (AveragePoints_i + 1) \times BaseAmount_t$$

The scheme is financed through a capitalized value system: Pensions are paid out from a pension insurance fund, to which premiums are paid by the employers. The employer makes a lump-sum payment to the insurance fund upon retirement so the system can be seen as partly funded.

In the post-reform scheme (*Avtalspension SAF-LO*), the pension contribution is 4.5 percent of the working-age individual's income up to 7.5 (income-related) base amounts and 30 percent of the income above 7.5 (income-related) base amounts.[16] The individual chooses whether to invest contributions in funds or in a traditional pension insurance with guaranteed interest. The scheme is financed through a premium reserve system, which means that pension benefits are paid out from invested assets rather than from current contributions.

There is a gradual phase-in of the new occupational pension system for blue-collar workers. Individuals born in 1931 or earlier are completely in the pre-reform scheme, whereas individuals born in 1968 or later are completely in the post-reform scheme. Individuals born 1932-1967 are subject to special transition rules: Their pension benefits are based on a combination of accumulated pension points in the pre-reform scheme and contributions to the post-reform scheme since 1996. We have not been able to find the details of these transition rules using online sources and published articles/reports. For the purpose of our analysis, we assume a linear phase-in of the post-reform scheme

[16] These percentages have increased over the years. In 2006, the contribution was 3.5 percent of incomes up to 7.5 (income-related) base amounts. Between 2008 and 2012, it increased gradually from 3.9 to 4.5 percent. During the same period, the contribution of incomes above 7.5 (income-related) base amounts increased gradually from 6 to 30 percent.

starting in 1996, when we assume that the reform was announced. We also let the contribution rate increase step-wise.

Occupational pensions for white-collar workers

Private sector white-collar workers typically work in professional services or management and are covered by the occupational pension scheme for white-collar workers. In the pre-reform scheme (*ITP2*), the pension benefit is calculated based on the individual's income in the year before retirement. The benefit equals 10 percent of the income up to 7.5 (income-related) base amounts, 65 percent of the income above 7.5 and up to 20 (income-related) base amounts, and 32.5 percent of the income above 20 and up to 30 (income-related) base amounts. The scheme is financed through a premium reserve system where pension benefits are paid out from invested assets.

Furthermore, there is a supplementary funded scheme (*ITPK*), in which the pension contribution is 2 percent of the individual's labor income. The individual chooses whether to invest contributions in funds or in a traditional pension insurance with guaranteed interest.

In the post-reform scheme (*ITP1*), the pension contribution is 4.5 percent of the working-age individual's income up to 7.5 (income-related) base amounts and 30 percent on the income above 7.5 (income-related) base amounts. The individual invests part of the contributions in funds, whereas the rest is invested in a traditional pension insurance with guaranteed interest. The scheme is financed through a premium reserve system.

Individuals born in 1978 or earlier are completely in the pre-reform scheme, whereas individuals born in 1979 or later are completely in the post-reform scheme. The reform was decided in 2006 and implemented in 2007.

B Model

B.1 Disposable labor and pension income

Disposable labor income during working life

Pension contributions and benefits are based on the gross labor income that is paid out to workers, denoted $Y_{i,h}^{\tau}$ for individual i of age $h \in [1, H_{ret}]$ and type τ. To simplify notation, the subscript i is dropped below. We define the total labor cost per worker as:

$$\hat{Y}_h^{\tau} \equiv (1+\lambda) Y_h^{\tau} \tag{22}$$

where λ denotes the pension contribution rate. We assume that unless there was a pension system, this total labor cost would be paid out to workers and correspond to gross labor income. This assumption implies that changes in the contribution rate λ are borne by workers and affect disposable income during working life.

We further assume that $\hat{Y}_h^{\tau}$ is given by the production technology and is constant over time. In practice, we let $\hat{Y}_h^{\tau}$ be determined by gross labor income in year T_0, which is the starting year for our analysis. We define disposable income during working life as:

$$Y_h^{\tau,net} \equiv \hat{Y}_h^{\tau} - \lambda Y_h^{\tau}. \tag{23}$$

On a balanced growth path, $Y_h^{\tau,net} = Y_h^{\tau}$. During the transition, however, Y_h^{τ} and $Y_h^{\tau,net}$ can differ. For workers of age $h \in [1, H_{ret}]$ and type τ in year t, we have that:

$$Y_{h,t}^{\tau,net} = \hat{Y}_{h,T_0}^{\tau} - \lambda_t Y_{h,t}^{\tau} \quad \forall t = [T_0, \infty) \tag{24}$$

where T_0 is the starting year of our analysis.

Disposable labor and pension income in pre and post-reform pension systems

Disposable labor and pension income in the pre-reform pension system is given by:

$$Y_h^{\tau,net} = \begin{cases} \hat{Y}_h^{BC} - (\lambda_h^{pub} + \lambda_h^{BC,occ}) Y_h^{BC} & \text{if } h < H_{ret} \text{ and } \tau = BC \\ \hat{Y}_h^{WC} - (\lambda_h^{pub} + \lambda_h^{WC,occ} + \lambda^{itpk}) Y_h^{WC} & \text{if } h < H_{ret} \text{ and } \tau = WC \\ Y^{pub} + Y^{BC,occ} & \text{if } h \geq H_{ret} \text{ and } \tau = BC \\ Y^{pub} + Y^{WC,occ} + Y^{f} & \text{if } h \geq H_{ret} \text{ and } \tau = WC \end{cases} \tag{25}$$

where λ_h^{pub} is the contribution rate to the public PAYGO scheme, $\lambda_h^{\tau,occ}$ is the contribution rate to the occupational PAYGO scheme, and λ^{itpk} is the contribution rate to the occupational funded scheme for white-collar workers. Y^{pub} denotes pension income from the public scheme (including the basic allowance $\underline{Y}^O$), $Y^{\tau,occ}$ denotes pension income from the occupational PAYGO schemes, and Y^f denotes pension income from the occupational funded scheme for white-collar workers.

Disposable labor and pension income in the post-reform pension system is given by:

$$Y_h^{\tau,net} = \begin{cases} \hat{Y}_h^\tau - (\lambda^p + \lambda^f + \xi_h)Y_h^\tau & \text{if } h < H_{ret} \text{ and } Y_h^\tau \leq \overline{Y} \\ \\ \hat{Y}_h^\tau - (\lambda^p + \lambda^f + \xi_h)\overline{Y} & \\ -(\overline{\lambda}^f + \xi_h)(Y_h^\tau - \overline{Y}) & \text{if } h < H_{ret} \text{ and } Y_h^\tau > \overline{Y} \\ \\ \max\{\underline{Y}^N, Y^p\} + Y^f & \text{if } h \geq H_{ret} \end{cases} \tag{26}$$

where λ^p is the contribution rate to the public PAYGO scheme, λ^f is the contribution rate to the public and occupational funded schemes below the income ceiling $\overline{Y}$, ξ_h is the tax rate needed to fund the minimum guaranteed pension $\underline{Y}^N$, and $\overline{\lambda}^f$ is the contribution rate to the occupational funded scheme above the income ceiling $\overline{Y}$. Y^p and Y^f denote the pension income from the public PAYGO scheme and the funded schemes, respectively.

B.2 Pension income

Pension income in pre-reform system

As described in Section 2, pension income (in base amounts) from the old public system is given by:

$$Y^{pub} = \underline{Y}^O + \rho\overline{PP}_{H_{ret}-1} \tag{27}$$

where $\underline{Y}^O$ is the basic allowance and ρ is the replacement rate in terms of average pension points from the $m = 15$ highest income-years prior to retirement ($\overline{PP}_{H_{ret}-1}$). Pension points ($PP$) are collected prior to retirement and equal to the amount of labor income between one base amount and a ceiling of $\bar{Y} = 7.5$ base amounts:

$$PP_h = \max\{0, \min\{\overline{Y} - 1, Y_h - 1\}\} \quad \text{if } h < H_{ret}. \tag{28}$$

To economize on state variables, we approximate the average pension points from the highest income-years by the formula used in French (2003, 2005):

$$\overline{PP}_h = \begin{cases} \frac{1}{h}\left[(h-1)\overline{PP}_{h-1} + PP_h\right] & \text{if } h \leq m \\ \frac{1}{m}\left[(m-1)\overline{PP}_{h-1} + \max\{\overline{PP}_{h-1}, PP_h\}\right] & \text{if } m < h \leq H_{ret} - 1 \\ \overline{PP}_{H_{ret}-1} & \text{otherwise.} \end{cases} \tag{29}$$

Instead of keeping track of the vector of all prior years of labor income, this approximation ensures that only $\overline{PP}_h$ is a state variable at each age h. Prior to retirement when $h \leq m$, $\overline{PP}_h$ equals the weighted mean of $\overline{PP}_{h-1}$ and PP_h, with weights $(h-1)/h$ and $1/h$, respectively. When $h > m$, $\overline{PP}_h$ is updated to a higher value if labor income in h is sufficiently high, such that $PP_h > \overline{PP}_{h-1}$. If that is the case, the state variable is updated to the weighted average of $\overline{PP}_{h-1}$ and PP_h, with weights $(m-1)/m$ and $1/m$, respectively. Since, in reality, a high-income year replaces a low-income year, this approximation will underestimate the average pension points.

As described in Appendix A.2, pension income (in base amounts) from the occupational scheme for blue-collar workers is given by:

$$Y^{BC,occ} = \rho^{BC} \left(\overline{PP}^{BC}_{H_2^{BC}} + 1 \right) \tag{30}$$

where ρ^{BC} is the replacement rate in terms of average pension points from the $m^{BC} = 3$ highest income-years between ages $H_1^{BC} = 55$ and $H_2^{BC} = 59$. Again, we use an approximation to keep track of one state variable at each age:

$$\overline{PP}^{BC}_h = \begin{cases} 0 & \text{if } h < H_1^{BC} \\ \frac{1}{h} \left[(h-1)\overline{PP}^{BC}_{h-1} + PP_h \right] & \text{if } H_1^{BC} \leq h < H_1^{BC} + m^{BC} \\ \frac{1}{m^{BC}} \left[(m^{BC}-1)\overline{PP}^{BC}_{h-1} + \max\{\overline{PP}^{BC}_{h-1}, PP_h\} \right] & \text{if } H_1^{BC} + m^{BC} \leq h < H_2^{BC} \\ \overline{PP}^{BC}_{H_2^{BC}} & \text{otherwise.} \end{cases}$$

As described in Appendix A.2, pension income from the PAYGO occupational scheme for white-collar workers is given by:

$$Y^{WC,occ} = \begin{cases} \rho_1^{WC} \min\{\overline{Y}, Y^{WC}_{H_{ret}-1}\} \\ +\rho_2^{WC} \left(\max\{0, Y^{WC}_{H_{ret}-1} - \overline{Y}\} - \max\{0, Y^{WC}_{H_{ret}-1} - \overline{Y}_2^{WC}\} \right) \\ +\rho_3^{WC} \left(\max\{0, Y^{WC}_{H_{ret}-1} - \overline{Y}_2^{WC}\} - \max\{0, Y^{WC}_{H_{ret}-1} - \overline{Y}_3^{WC}\} \right) \end{cases} \tag{31}$$

where ρ_1^{WC}, ρ_2^{WC}, and ρ_3^{WC} are the replacement rates on incomes below $\overline{Y}$, incomes between $\overline{Y}$ and $\overline{Y}_2$, and incomes between $\overline{Y}_2$ and $\overline{Y}_3$, respectively (where $\overline{Y} < \overline{Y}_2 < \overline{Y}_3$).

Pension wealth from the funded occupational scheme for white-collar workers ($ITPK$) evolves according to:

$$A^f_{h+1} = (1+r)A^f_h + \lambda^{itpk} Y_{h+1} \tag{32}$$

and this pins down pension income Y^f from this scheme. Specifically, Y^f equals the annuity of funded pension wealth prior to retirement ($A^f_{H_{ret}-1}$), given the maximum time in retirement

$(H - H_{ret} + 1)$ and the rate of return (r):

$$Y^f = \frac{(1+r)^{H-H_{ret}+1}}{\sum_{k=0}^{H-H_{ret}}(1+r)^k} A^f_{H_{ret}-1} \tag{33}$$

where funded pension wealth prior to retirement is given by:

$$A^f_{H_{ret}-1} = (1+r)^{H_{ret}-1} A^f_0 + \sum_{h=1}^{H_{ret}-1} (1+r)^{(H_{ret}-1)-h} \lambda^{itpk} Y_h. \tag{34}$$

We assume that individuals start with no funded pension wealth: $A^f_0 = 0$.

Pension income in post-reform system

Pension income from funded pension wealth Y^f is given by Equation 33 for both public and occupational schemes. Pension income from the public NDC scheme is given by:

$$Y^p = \frac{(1+g)^{H-H_{ret}+1}}{\sum_{k=0}^{H-H_{ret}}(1+g)^k} A^p_{H_{ret}-1} \tag{35}$$

where g is the average wage growth, see Section 2.

The laws of motions for notional and funded pension wealth are:

$$A^p_{h+1} = (1+g)A^p_h + \lambda^p \min\{\overline{Y}, Y^\tau_{h+1}\} \tag{36}$$

$$A^f_{h+1} = \begin{cases} (1+r)A^f_h + \lambda^f Y^\tau_{h+1} & \text{if } Y^\tau_{h+1} \leq \overline{Y} \\ \\ (1+r)A^f_h + \lambda^f \overline{Y} & \\ +\overline{\lambda}^f (Y^\tau_{h+1} - \overline{Y}) & \text{otherwise} \end{cases} \tag{37}$$

and they pin down the values of pension wealth prior to retirement:

$$A^p_{H_{ret}-1} = (1+g)^{H_{ret}-1} A^p_0 + \sum_{h=1}^{H_{ret}-1} (1+g)^{(H_{ret}-1)-h} \lambda^p \min\{\overline{Y}, Y^\tau_h\} \tag{38}$$

$$\begin{aligned} A^f_{H_{ret}-1} &= (1+r)^{H_{ret}-1} A^f_0 \\ &+ \sum_{h=1}^{H_{ret}-1} (1+r)^{(H_{ret}-1)-h} \left(\lambda^f \min\{\overline{Y}, Y^\tau_h\} + \overline{\lambda}^f \max\{0, Y^\tau_h - \overline{Y}\}\right) \end{aligned} \tag{39}$$

where we again assume that initial pension wealth is zero: $A^p_0 = A^f_0 = 0$.

State variables that capture the pension system

In the pre-reform pension system, individuals of age $h \in [1, H]$ face the following set of state variables (in addition to the state variable capturing the permanent income component of gross labor income during working life):

$$\Psi_h^{\mathcal{O}} = \begin{cases} \{\overline{PP}_h, \overline{PP}_h^{BC}\} & \text{if blue-collar} \\ \{\overline{PP}_h, A_h^f\} & \text{if white-collar} \end{cases} \tag{40}$$

where $\overline{PP}_h$ denotes average pension points in the public system, $\overline{PP}_h^{BC}$ denotes average pension points in the occupational scheme for blue-collar workers, and A^f denotes funded pension wealth from the occupational scheme for white-collar workers ($ITPK$).

In the post-reform pension system, individuals face the following set of (additional) state variables:

$$\Psi_h^{\mathcal{N}} = \{A_h^p, A_h^f\} \tag{41}$$

where A_h^p denotes notional pension wealth from the public NDC scheme and A_h^f denotes funded pension wealth from both public and occupational schemes.

During the gradual phase-in of the new pension system, the state space of the transition cohorts consists of the union of the sets in the pre and post-reform pension systems:

$$\Psi_h^{\mathcal{R}} = \begin{cases} \{\overline{PP}_h, \overline{PP}_h^{BC}, A_h^p, A_h^f\} & \text{if blue-collar} \\ \{\overline{PP}_h, A_h^p, A_h^f\} & \text{if white-collar.} \end{cases} \tag{42}$$

B.3 Pension provider

Pension provider in pre-reform system

In each year, the pension provider balances the public and occupational defined benefit schemes by solving for the contribution rates λ^{pub} and $\lambda^{\tau,occ}$. We assume that the rate at which young individuals of age H_0 enter the labor force is n and that the share of blue-collar workers relative to the total labor force is exogenous and equal to χ. The balanced budget condition for the public scheme is then given by:

$$\sum_{h=1}^{H_{ret}-1} \Phi_h(1+n)^{H-h}\left(\chi CO^{BC} + (1-\chi)CO^{WC}\right) = \sum_{h=H_{ret}}^{H} \Phi_h(1+n)^{H-h}\left(\chi PI^{BC} + (1-\chi)PI^{WC}\right) \tag{43}$$

where Φ_h is the unconditional survival probability at age h, CO^τ denotes the contributions paid in by workers of type τ, and PI^τ denotes the pension income of retirees of type τ.

Contributions paid in by workers to the public scheme are given by:

$$CO^\tau = \int \lambda^{pub} Y \, d\Omega(Z, h, \tau) \tag{44}$$

and pension income paid out to retirees from the public scheme is given by:

$$PI^{\tau} = \int Y^{pub} \, d\Omega(Z, h, \tau) \tag{45}$$

where $\Omega(Z, h, \tau)$ is the distribution of individuals of age h and type τ with state space Z.

The pension provider balances the occupational defined benefit schemes within occupational groups, so that blue-collar (white-collar) workers fund occupational pensions for blue-collar (white-collar) retirees. The balanced budget condition for each worker type is given by:

$$\sum_{h=1}^{H_{ret}-1} \Phi_h (1+n)^{H-h} \int \lambda^{\tau,occ} Y \, d\Omega(Z, h, \tau) = \sum_{h=H_{ret}}^{H} \Phi_h (1+n)^{H-h} \int Y^{\tau,occ} \, d\Omega(Z, h, \tau). \tag{46}$$

Pension provider in post-reform system

The pension provider solves for the tax rate ξ needed to fund the minimum guaranteed pension $\underline{Y}^N$ using a similar balanced budget condition as in Equation (43), with worker contributions and pension incomes given by:

$$CO^{\tau} = \int \xi Y \, d\Omega(Z, h, \tau) \tag{47}$$

$$PI^{\tau} = \int \underline{Y}^N - Y^p \, d\Omega(\tilde{Z}, h, \tau) \tag{48}$$

where $\tilde{Z}$ is the distribution of individuals with public pension incomes Y^p lower than the minimum guaranteed pension income $\underline{Y}^N$. The revenues from the tax are thus used to top up the incomes of individuals with low public pension incomes such that all individuals effectively get at least the minimum guaranteed pension during retirement.

B.4 Additional tables and figures

Life cycle profiles

Figure 8: Net life cycle labor and pension income for cohorts 1937 (dashed) and 1938 (solid), for white-collar (left) and blue-collar (right) workers, respectively.

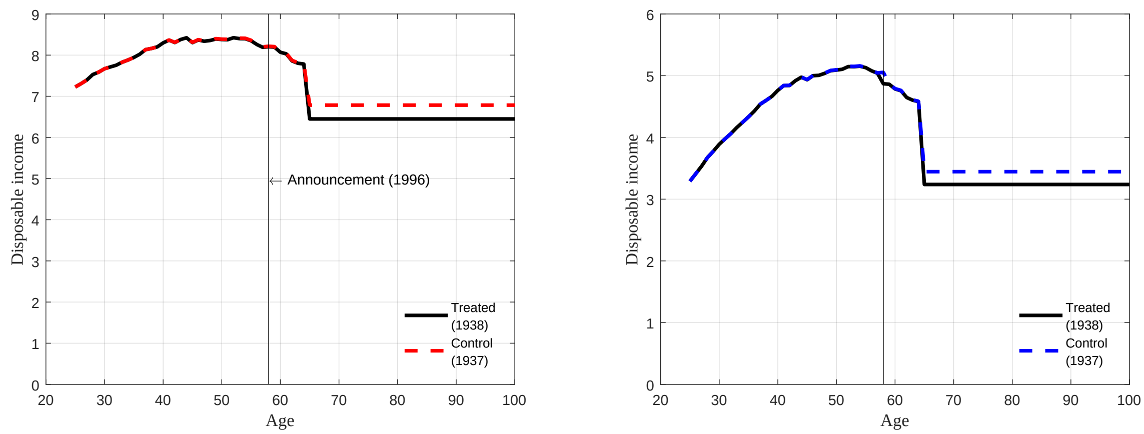
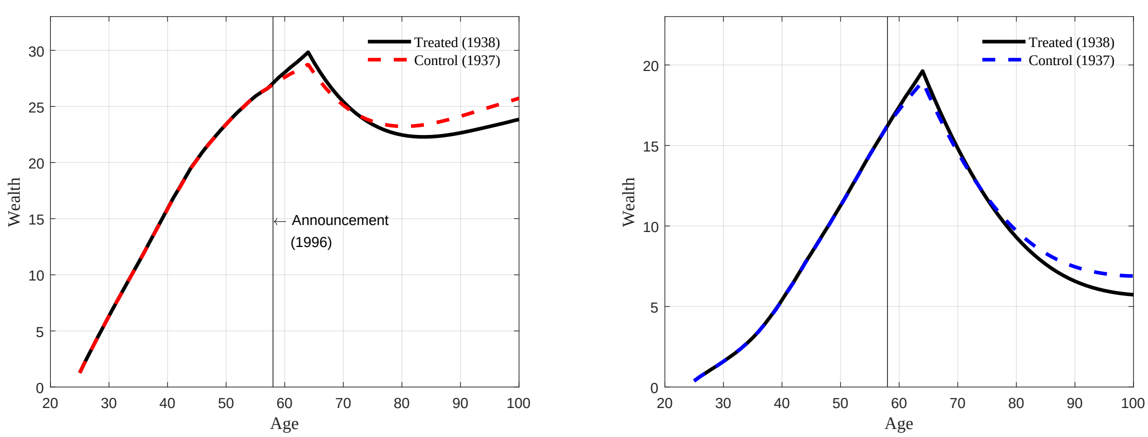


Figure 9: Net life cycle wealth for cohorts 1937 (dashed) and 1938 (solid), for white-collar (left) and blue-collar (right) workers, respectively.



Regressions on actual and simulated data

Figure 10: Net wealth in 2005 for unaffected cohorts (red) and affected cohorts (blue). Left panel shows results from model simulation and left panel shows results from administrative data. Values are scaled by the values of the fitted regression lines.

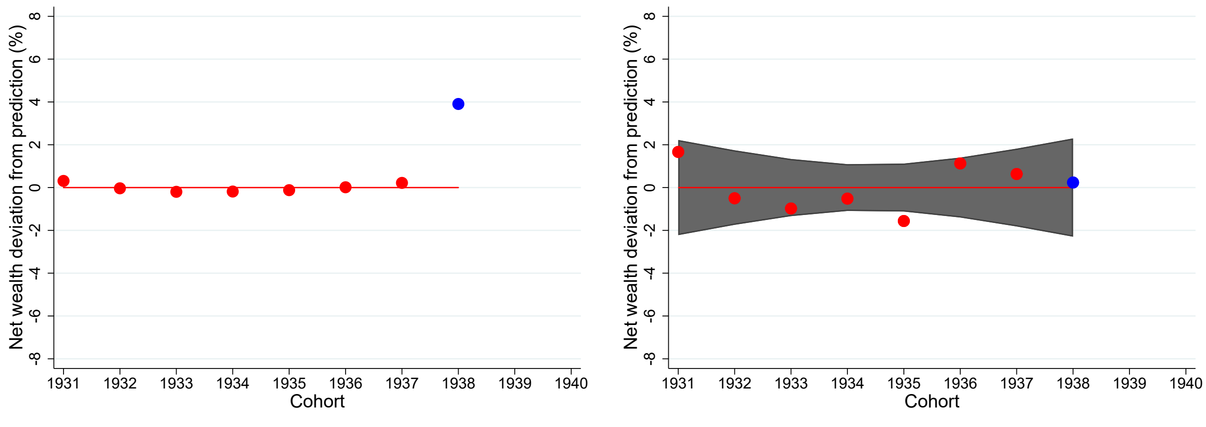


Figure 11: Savings rates in 2005 for unaffected cohorts (red) and affected cohorts (blue). Left panel shows results from model simulation and left panel shows results from administrative data. Values are scaled by the values of the fitted regression lines.

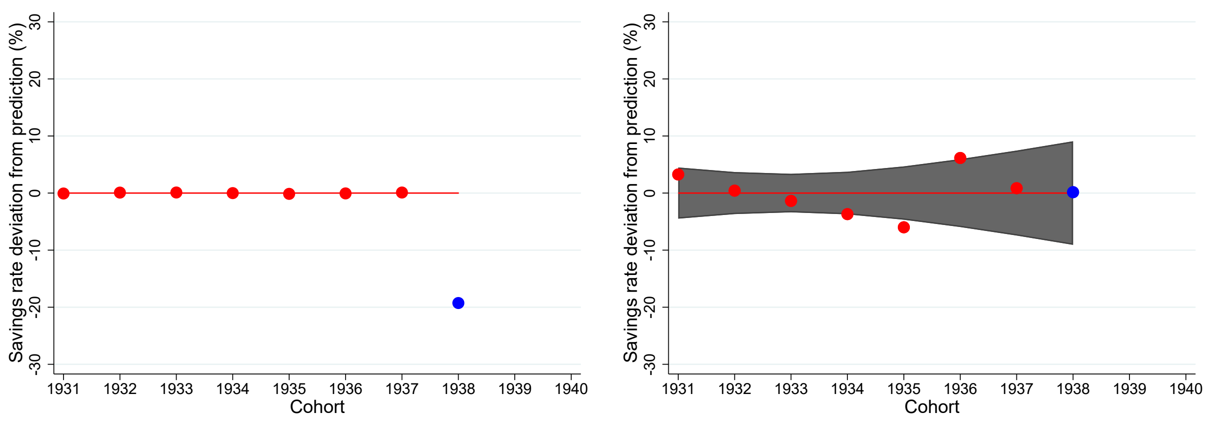


Figure 12: Net wealth in 2006 for unaffected cohorts (red) and affected cohorts (blue). Left panel shows results from model simulation and left panel shows results from administrative data. Values are scaled by the values of the fitted regression lines.

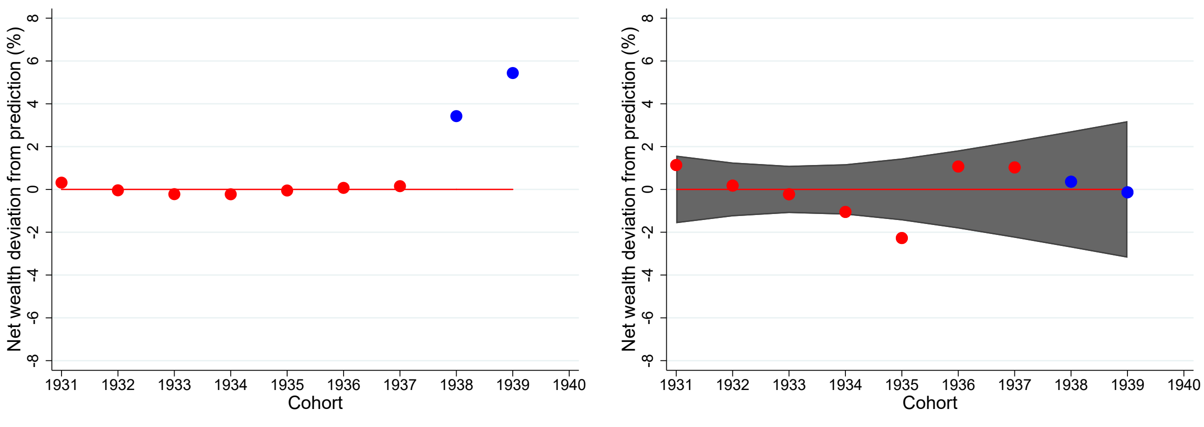
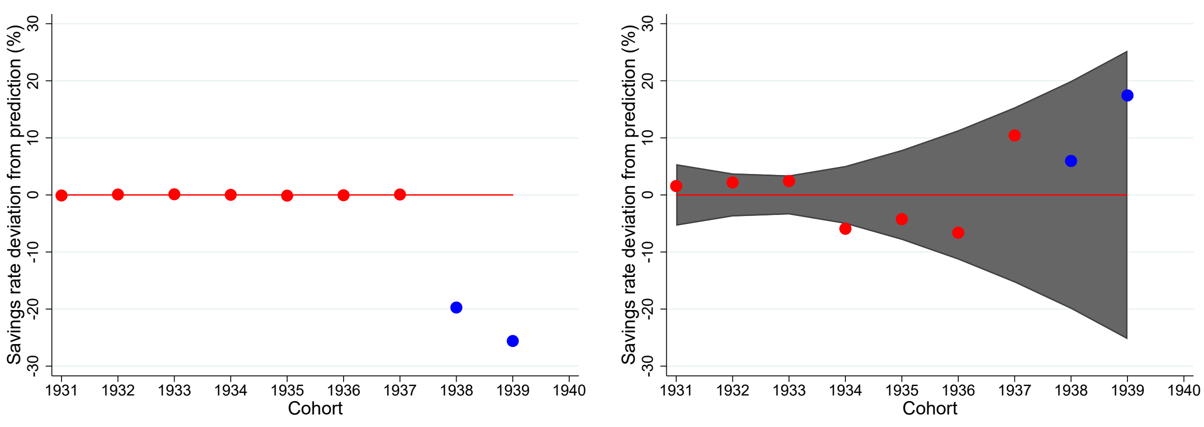


Figure 13: Savings rates in 2006 for unaffected cohorts (red) and affected cohorts (blue). Left panel shows results from model simulation and left panel shows results from administrative data. Values are scaled by the values of the fitted regression lines.



B.5 Robustness checks

No bequests.

Table 8: Wealth moments to match.

Description	**Value**
Total A of 63–65 year-olds / Total Y of 63–65 year-olds	4.07
	(0.48)

Note: A denotes net wealth and Y denotes gross labor income. Each moment is given by its average across years 2000–2007. Numbers in parentheses denote the standard errors of the time series during the same period.

Table 9: Calibrated parameters.

Parameter	Description	Value
δ	Exponential discount factor	0.985

Note: These parameters are calibrated by matching simulated data from the model to the moments in Table 10.

Table 10: Model estimates.

	Standard model (SM)	SM w/ present bias	SM w/ inattention
Exponential discount factor (δ)	0.974	0.974	0.972
Naive hyperbolic discount factor (β)		1.000	
Share of inattentive agents (α)			0.882
Number of moments	10	10	10
Number of free parameters	1	2	2
Goodness of fit	2.18×10^8	2.18×10^8	1.08×10^8

Note: Estimates for models without a bequest motive. The goodness of fit measure includes a weighting matrix equal to inverse of diagonal of standard errors in data.

Free parameters.

Table 11: Model estimates.

	Present bias	Inattention
Exponential discount factor (δ)	1.00	1.00
Bequest weight (ν_1)	151.14	43.08
Luxury component of bequests (ν_2)	52.90	1.06
Naive hyperbolic discount factor (β)	1.00	
Share of inattentive agents (α)		0.96
Number of moments	12	12
Number of estimated parameters	4	4
Goodness of fit	3.12×10^6	1.37×10^6

Note: In all entries with no reported number, $\beta = 1$ and $\alpha = 0$ by assumption. Standard errors are not reported because estimates are at the boundary. Weighting matrix is equal to the inverse of a diagonal matrix with a diagonal equal to the variances implied by the reported standard errors. Inattentive agents expect to get the share $\mu = 0.70$ of permanent income in the last working age ($P^{net}_{H_{ret}-1}$) as retirement income.

B.6 Equilibrium definitions

In any pension system, individuals are heterogeneous with respect to type $\tau \in \{WC, BC\}$, age $h \in \mathcal{H} = \{1, 2, ..., H\}$, birth year $j \in \mathcal{J} = [J_0, J]$ (or year $t = j + h$), persistent earnings component $P \in \mathcal{P} = \mathbb{R}_{++}$, and cash-in-hand $X \in \mathcal{X} = \mathbb{R}_{++}$, where cash-in-hand for worker type τ of age h is defined as the sum of liquid financial wealth and net labor income: $X_h = (1+r)A_{h-1} + Y_h^{\tau,net}$.

In the old pension system, both type of workers ($\tau \in \{WC, BC\}$) are also heterogeneous with respect to average pension points from the $m = 15$ best income years prior to retirement, H_{ret}: $\overline{PP} \in \mathcal{PP} = \mathbb{R}_+$. In addition, blue-collar workers ($\tau = BC$) are heterogeneous with respect to average pension points from the $m^{BC} = 3$ best income years between ages $H_1^{BC} = 55$ and $H_2^{BC} = 59$: $\overline{PP}^{BC} \in \mathcal{PP}^{\mathcal{BC}} = \mathbb{R}_+$; while white-collar workers ($\tau = WC$) are heterogeneous with respect to funded pension wealth $A^f \in \mathcal{A}^{\mathcal{F}} = \mathbb{R}_+$.

In contrast to the old pension system, individuals in the new pension system are heterogeneous with respect to notional defined-contribution PAYGO wealth $A^p \in \mathcal{A}^{\mathcal{P}} = \mathbb{R}_+$. Also, both type of workers, and not only white-collar workers, are heterogeneous with respect to funded pension wealth, $\mathcal{A}^{\mathcal{F}}$.

Let $\mathcal{Z} = \{\mathcal{P} \times \mathcal{X} \times \mathcal{PP} \times \mathcal{PP}^{\mathcal{BC}} \times \mathcal{A}^{\mathcal{F}} \times \mathcal{A}^{\mathcal{P}}\}$ be the non-deterministic state space with $\mathbf{z} = (P, X, \overline{PP}, \overline{PP}^{BC}, A^f, A^p)$ denoting the vector of individual states. Let $\mathbf{B}(\mathbb{R}_+)$ and $\mathbf{B}(\mathbb{R}_{++})$ be the Borel σ-algebras on $\mathbb{R}_+$ and $\mathbb{R}_{++}$, respectively, and let $B(\mathcal{Z}) = \{\mathbf{B}(\mathbb{R}_{++}) \times \mathbf{B}(\mathbb{R}_{++}) \times \mathbf{B}(\mathbb{R}_+) \times \mathbf{B}(\mathbb{R}_+) \times \mathbf{B}(\mathbb{R}_+) \times \mathbf{B}(\mathbb{R}_+)\}$. If $\mathbb{M}$ is the set of all finite measures over the measurable space $(\mathcal{Z}, B(\mathcal{Z}))$, then $\Omega(Z, h, \tau) \in \mathbb{M}$ is a probability measure defined on subsets $Z \in B(\mathcal{Z})$ that describes the distribution of individual states across agents with age $h \in \mathcal{H}$ and of type $\tau \in \{BC, WC\}$.

Since states A^f and A^p are redundant for blue-collar workers in the old pension system, the sparse state space can be expressed as $\mathcal{Z}^O = \{\mathcal{P} \times \mathcal{X} \times \mathcal{PP} \times \mathcal{PP}^{\mathcal{BC}}\}$ with $\mathbf{z^O} = (P, X, \overline{PP}, \overline{PP}^{BC})$ denoting the vector of individual states. For white-collar workers, PP^{BC} and W^p are redundant, so the sparse state space is $\mathcal{Z}^O = \{\mathcal{P} \times \mathcal{X} \times \mathcal{PP} \times \mathcal{A}^{\mathcal{F}}\}$ with $\mathbf{z^O} = (P, X, \overline{PP}, W^f)$ denoting the vector of individual states. Conversely, in the new pension system, the sparse state space and the vector of individual states can be expressed as $\mathcal{Z}^N = \{\mathcal{P} \times \mathcal{X} \times \mathcal{A}^{\mathcal{F}} \times \mathcal{A}^{\mathcal{P}}\}$ and $\mathbf{z^N} = (P, X, A^f, A^p)$ for both types of workers.

We refer to an equilibrium with an exogenous interest rate r as being a *partial equilibrium*, and we refer to an equilibrium where aggregate variables grow with constant rates as being a *balanced growth equilibrium*. Although there is no productivity growth, the model permits a balanced growth equilibrium if there is a positive population growth.

Balanced growth equilibrium with the old pension system

A *partial balanced-growth recursive equilibrium with the old pension system* is a collection of value functions $V_h^{\mathcal{O}}(\mathbf{z^O})$ with associated policy functions $C_h^\tau(\mathbf{z^O})$ and $A_h^\tau(\mathbf{z^O})$ for all h and τ, contribution rates to the public and occupational schemes λ^{pub} and $\lambda^{\tau,occ}$, and a distribution of states $\Omega(Z^O, h, \tau)$ for all h and τ such that

- $V_h^{\mathcal{O}}(\mathbf{z^O})$ solves (9) for all h;
- λ^{pub} solves the balanced budget condition (43), satisfying (44) and (45), and $\lambda^{\tau,occ}$ solves (46) for all τ;
- the distribution of states $\Omega(Z^O, h, \tau)$ is given by the following law of motion for all h and τ

$$\Omega(\mathcal{Z}^O, h+1, \tau) = \int_{Z^O} Q_h(\mathbf{z^O}, \mathcal{Z}^O) d\Omega(Z^O, h, \tau)$$

  where $Q_h : \mathcal{Z}^O \times \mathcal{B}(\mathcal{Z}^O) \to [0,1]$ is a transition function that defines the probability that an agent transits from its current state $\mathbf{z^O}$ to the set $\mathcal{Z}^O$.

Balanced growth equilibrium with the new pension system

A *partial balanced-growth recursive equilibrium with the new pension system* is a collection of value functions $V_h^{\mathcal{N}}(\mathbf{z^N})$ with associated policy functions $C_h^\tau(\mathbf{z^N})$ and $A_h^\tau(\mathbf{z^N})$ for all h and τ, a pension tax ξ that finances minimum guaranteed pension payments, and a distribution of states $\Omega(Z^N, h, \tau)$ for all h and τ such that

- $V_h^{\mathcal{N}}(\mathbf{z^N})$ solves (9) for all h and τ.
- ξ solves the balanced budget condition (43), satisfying (47) and (48).
- The distribution of states $\Omega(Z^N, h, \tau)$ is given by the following law of motion for all h and τ

$$\Omega(\mathcal{Z}^N, h+1, \tau) = \int_{Z^N} Q_h(\mathbf{z^N}, \mathcal{Z}^N) d\Omega(Z^N, h, \tau)$$

Transitional equilibrium with the old system

A *partial transitional recursive equilibrium with the old system* is a collection of the same objects as in the balanced growth equilibrium with the old pension system, augmented by a year-index $t \in [T_0, T]$, and time-varying vectors for birth rates $\{n_t\}_{t\in[T_0,T]}$ and survival rates $\{\phi_{h,t}\}_{t\in[T_0,T]}$, for all h, which determine the demographic transition between $[T_0, T]$. The economy permits a balanced growth equilibrium with the old pension system for the years before T_0 and after T.

Transitional equilibrium with the pension reform

A *partial transitional recursive equilibrium with the pension reform* is a collection of (i) the same birth and survival rates as in the partial transitional recursive equilibrium with the old system; (ii) implementation rules $\{T_{ann}, I^\tau\}$, where $T_{ann} \in (T_0, T)$ is the announcement year at which agents are informed about the reform and I^τ is an implementation rule specifying the years in which the old pension systems are replaced by the new pension systems for each worker type τ.

B.7 Numerical solution

The individual problem cannot be solved analytically. As there are up to eight exogenous state variables (worker type τ, age h, cohort j (or time $t = j + h$), persistent income P, average pension points for the public scheme $\overline{PP}$, average pension points for the blue-collar scheme $\overline{PP}^{BC}$, NDC PAYGO wealth A^p and funded pension wealth A^f) and only one endogenous state variable (cash-in-hand X), we use a version of the endogenous grid point method (EGM) in Carroll (2006) proposed by Almerud and Österling (2017): The stochastic endogenous grid point method (S-EGM). This solution method consists of two modifications to the standard EGM. First, the grids for exogenous state variables are created by simulating paths of the stochastic processes before solving the model. Second, instead of using a multivariate linear interpolation over all state variables, the method uses nearest-neighbor interpolation over the exogenous state variables to find the simulated path that best represents the environment in which the expectation is calculated. For more details on the solution method, see Almerud and Österling (2017).

C Empirics

C.1 Administrative data

Financial assets

The Swedish tax authority collected data on taxpayers' holdings of financial assets directly from financial institutions. Data on debt includes credit card debt, car loans, student loans, and mortgages. The subcategories are not observed individually except for student loans. Data on bank account holdings includes holdings in checking accounts, savings accounts, and certificates of deposit.[17] Data on mutual funds, stocks, and bonds is reported at the individual security level. Each security is identified by its ISIN (International Securities Identification Number). In rare instances, the Swedish firm ID number was reported instead, requiring a careful matching procedure by hand. The so called capital insurance accounts were subject to a special tax treatment. As a consequence, we observe the annual account balance on these accounts but not the holdings of individual securities. The so called privat pension accounts were also subject to a special tax treatment in this period. For these accounts, we observe the net flows into the accounts but not the annual account balances.

Real estate assets

For the purpose of our analysis, we include real estate assets in the form of (single-family) houses, tenant-owned apartments (co-ops), and second homes (cabins). Other types of real estate assets are excluded, see Appendix C.2.

For houses and cabins, the Swedish tax authority determines registered property values used for tax purposes. This value is determined by a detailed set of property characteristics and is updated every three years. Statistics Sweden then estimates market values for all individual properties based on the ratio of observed market values to tax values for transacted properties. This ratio is computed at the municipality level. The estimated market values are likely to result in accurate valuations of houses and cabins on average. However, property-specific deviations from the estimated market values are a source of measurement error.

For co-ops, the Swedish tax authority does not determine registered property values. Statistics

[17] Financial institutions were required to report bank account holdings to the tax authority if the annual interest on holdings exceeded SEK 100 (roughly USD 10) until 2004. After 2004, the reporting requirement was instead if holdings exceeded SEK 10,000. This shift in reporting requirement implies less missing data on bank account holdings after 2004. Nevertheless, several financial institutions reported bank account holdings below the required thresholds throughout the period.

Sweden therefore uses the average sales value in a given co-op in a given year to assign market values to all apartments in that co-op. If too few sales occur at the co-op level, the average sales value in the neighbourhood (parish) is used instead. This procedure results in large apartments being undervalued, small apartments being overvalued and in too little variation in apartment values overall.

Other administrative data

To compute savings rates, we want a measure of total disposable income. We use the variable for disposable income from Statistics Sweden (CDISP and CDISP04) and remove net increases in student loans and net capital gains. This results in a measure of disposable income that is net of taxes and includes labor income, pension income, and capital income. Capital income includes interest income from bank account holdings, dividends from stocks, and coupon payments from bonds.

For our sample restrictions (see Appendix C.2) we furthermore use information on the primary residence of individuals, as well as a variable indicating changes of this primary residence. We also use institutional sector codes (ISIC/NACE) to identify individuals who primarily work in farming.

C.2 Sample restrictions

These sample restrictions are shown for the sample of individuals born between 1931 and 1940.

We impose the following sampling restrictions on our data. First, we exclude individuals who are not registered in a Swedish municipality but likely have their main residence abroad. Second, we exclude individuals who work in farming (based on the ISIC/NACE code) or as entrepreneurs, defined as individuals who report more than 50,000 SEK in annual income from an own business. For these individuals, personal and business assets may be hard to separate. Third, we exclude individuals who hold derivatives which are hard to value correctly. Fourth, we exclude individuals who have reported securities for which we do not know the ISIN or the price. Fifth, we exclude individuals who report a return on their portfolio of mutual funds, stocks, and bonds in the bottom 1 percent or the top 1 percent of the return distribution. Sixth, we exclude individuals who own commercial real estate. Similar to farmers and entrepreneurs, personal and business assets may be hard to separate. Seventh, we exclude individuals with negative reported total disposable income. This is because the computation of savings rates becomes somewhat meaningless for these individuals. Eighth, we exclude individuals that hold more than SEK 10 million in net wealth. This restriction is imposed to exclude the tail of high-wealth individuals who may have a large impact on results. Table 12 shows the effect of these sample restrictions on the number of observations in the sample used for analyzing net wealth.

Table 12: Sample restrictions for analysis of net wealth

Step	Description	No. of obs.
0	Full sample	6 370 190
1	Resident in Sweden	6 261 476
2	No farmers or entrepreneurs	6 138 339
3	No hard-to-value derivatives	6 109 810
4	No missing ISIN or price of security	5 616 921
5	No extreme portfolio returns	5 575 223
6	No ownership of commercial real estate	4 996 160
7	No negative disposable income	4 945 403
8	No net wealth above SEK 10 million	4 942 925

Additional restrictions for analyzing savings flows and savings rates

In addition to the restrictions above, we impose a number of additional restrictions on the sample used for analyzing savings flows and savings rates. The full sample contains fewer observations since we are not able to compute savings flows and savings rates for the year 2000.

We exclude individuals who are likely to have transacted housing. These individuals are identified through a combination of a change in their main residence and a large change in the value of their property. We define a large change in the value of their property as a more than 15 percent deviation from the value that would have resulted if the average price change in their municipality had prevailed. We also exclude individuals with a very large change in net wealth between years, corresponding to the bottom 2.5 percent and the top 2.5 percent of the year-specific net wealth distribution. Large changes in net wealth between years could happen for many reasons, such as bequests or intervivos transfers from family members which we do not observe. Finally, we exclude individuals with a savings rate in the bottom 2.5 percent or the top 2.5 percent of the year-specific savings rate distribution. Extreme savings rates can occur if individuals receive bequests or intervivos transfers from family members which we do not observe.

Table 13 shows the effect of sample restrictions on the number of observations in the sample used for analyzing savings flows and savings rates.

Table 13: Sample restrictions for analyzing savings flows and savings rates

Step	Description	No. of obs.
0	Full sample	5 538 791
1	Resident in Sweden	5 441 001
2	No farmers or entrepreneurs	5 340 317
3	No housing transactions	4 329 736
4	No hard-to-value derivatives	4 311 788
5	No missing ISIN or price of security	3 981 917
6	No extreme portfolio returns	3 953 158
7	No extreme changes in net wealth	3 846 904
8	No ownership of commercial real estate	3 435 456
9	No negative disposable income	3 413 334
10	No extreme savings rates	3 242 780
11	No net wealth above SEK 10 million	3 242 614

C.3 Additional empirical results

Figure 14: Net wealth 2000–2007 (left) and savings rates 2001–2007 (right) for cohorts 1935–1940.

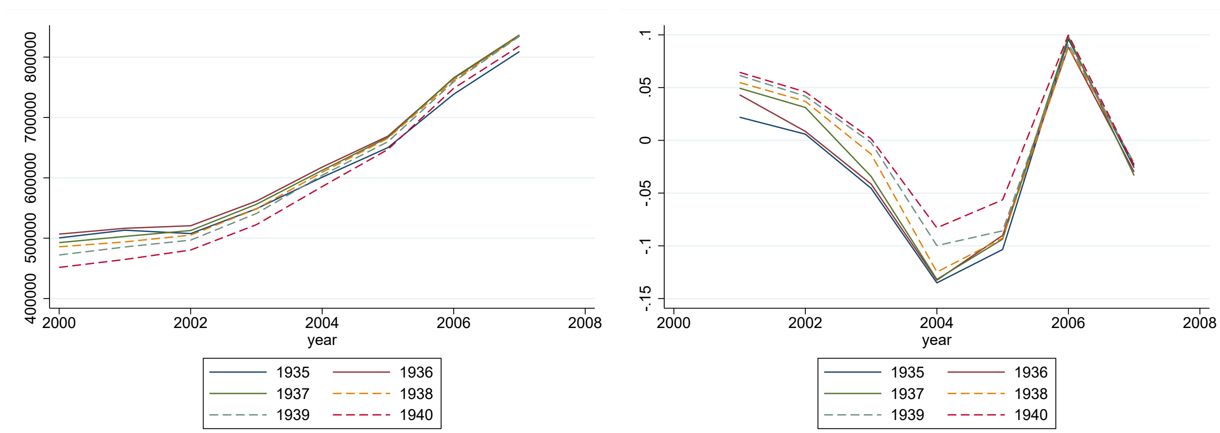


Figure 15: Returns in real estate (left panel) and risky financial assets (right panel) 2002–2007 for cohorts 1935–1940.