The impact of pension reform on household income and savings: A quantitative analysis of the Swedish case *

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Abstract

Increases in life expectancy cause challenges for defined benefit pension systems. Sweden is one of few countries having undertaken a major reform aimed at creating a financially sustainable pension system. Since the pension reform, the household savings rate has increased significantly. We investigate to which extent the pension reform can explain this increase. We construct a life-cycle model of heterogeneous agents which enables us to quantify the impact of the reform on household income and savings. The key feature of our framework is the explicit modeling of all aspects of the pension system including public pensions, occupational pensions and the minimum guaranteed pension. We find that the Swedish pension reform implies a major shift of income from retirement to working age and that it can explain about half of the observed increase in the private savings rate.

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1 Introduction

Increases in life expectancy will have a significant impact on pension systems over the next few decades. In OECD countries, the share of people aged above 65 relative to those of working age is expected to almost double between 2015 and 2050 (OECD, 2017). Unless there is a major increase in the retirement age, such a rise in life expectancy will cause challenges for pension systems promising defined benefits during retirement. For pay-as-you go (PAYGO) schemes to balance, the contribution rates among the working population may have to increase substantially.

As a consequence of projected demographics, governments around the world are trying to design more financially sustainable pension systems. Sweden is one of few countries having undertaken a major reform aimed at creating a financially sustainable public pension system. The new PAYGO scheme implies that lifetime labor income determines the future pension and that increases in life expectancy translate into a lower pension income. There is some evidence that the new system results in lower pensions, which may increase the motivation to save for retirement.[1] In fact, the gradual phasing-in of the new pension system does coincide with an upward trend in household savings. Since the start of the implementation of the occupational pension reform in 1996, the total household savings rate has increased by 10 percentage points and the private savings rate has increased by 8 percentage points; see Figure 1.[2] In this paper we study the impact of the Swedish pension reform on household incomes and savings. In particular, we want to understand how changes in the expected level of pension income and other features of the new pension system, such as changes in risk, affect the savings behavior.

The pension reform will not be completely phased in until around the year 2080 and its full effects on savings cannot yet be empirically evaluated. Therefore, we study the effect of the reform using a quantitative model of income and savings under the assumption of rational agents. We augment a standard life-cycle overlapping-generations model of a small open economy with a detailed description of the Swedish pension system. Markets are incomplete and agents face a borrowing constraint. Agents are heterogeneous in type – they are either blue-collar or white-collar workers – and face an uncertain life-span and idiosyncratic income shocks during their working life. This heterogeneity in income is important since pension contributions and benefits depend on the trajectories of income. Gross labor income is exogenous and disposable labor income is determined by pension contributions. We explicitly model all pillars of the pension system including the public pension system, minimum guaranteed pensions and occupational pensions negotiated between employers and labor unions. This detailed modeling is necessary to capture projected pension incomes for different income groups.[3]

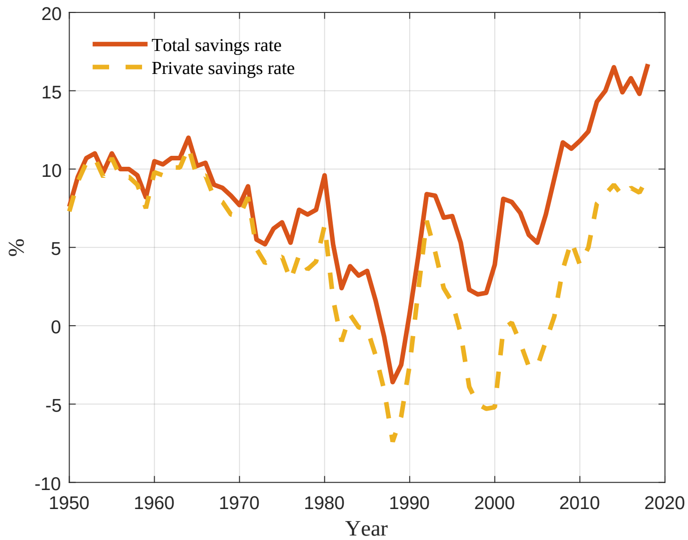
The most prominent result of the pension reform is that it redistributes income from retirement to

[1] See Pensionsmyndigheten (2017) for comparisons of pension incomes for cohorts born between 1938 and 1945.

[2] The aggregate savings rates are defined in Appendix 10.1.

[3] For the average-income earner, public pensions account for the majority of the pension income. For high-income earners, occupational pensions dominate whereas for low-income earners, the minimum guaranteed pension is important.

Figure 1: Household savings rate in Sweden (percent)



Notes: The total savings rate is savings relative to disposable income, where savings include funded pension savings from the PPM and occupational schemes. The private savings rate is savings relative to disposable income, where savings exclude funded pension savings from the PPM and occupational schemes. The total and private savings rates are defined in Appendix 10.1. Source: Statistics Sweden.

working life. This redistribution implies a lower average replacement rate, that is a lower average pension relative to final-year working age income. Although some blue-collar workers get higher pensions compared to the counterfactual scenario, the average replacement rate falls from 75 percent to 69 percent. Among white-collar workers, the entire pension income distribution shifts to the left and the average replacement rate drops from 84 percent to 61 percent. This shift in income profiles provides a stronger motivation for households to save for retirement in order to smooth consumption over the life-cycle.

The reform does not only cover future cohorts but also individuals who were of working age at the time of the reform announcement get part of their pension from the new system. We find that the reform on average implies a negative shock to the pension income for cohorts that are transferred from the old to the new pension system. As a consequence, many individuals find themselves in a situation with lower accumulated savings than desired and decide to increase their savings rate. These higher savings among working age individuals result in an increase of the aggregate savings rate at the time of the reform.

According to the model, the aggregate private savings rate increases by 4 percentage points between the reform announcement and the peak savings rate in 2006 as compared to the counterfactual scenario. This result means that the reform can account for about half of the increase in the private savings rate observed in the data. We also find that the total savings rate increases by 8 percentage points between the reform announcement and 2018 as compared to the counterfactual scenario. This means that the reform can account for approximately 80 percent of the observed increase in the total savings rate.

However, our model predicts that the entry of white-collar workers into the new occupational pension system in 2007 leads to a drop in the private savings rate. These workers face less uncertainty as their occupational pension is based on the entire stream of life-time labor income and not only on income in the final year. Hence, they have a lower motivation to accumulate precautionary savings for retirement. This means that the model does not explain the continuous increase in the private savings rate that we see in the data.

The Swedish pension reform is representative of the recent wave of reforms which aim at creating a closer connection between individual pension contributions and benefits as well as a shift towards arrangements in which assets back future pensions (OECD, 2016). Both the public scheme, covering all workers, and the occupational schemes, covering 90 percent of the workers, have been reformed in this direction. Although institutional details are country-specific, the Swedish reform provides an interesting case study for other countries considering similar types of changes in their pension systems.

This paper is related to a vast literature on social security design and its implications for savings; see Fehr (2009) for a survey of the earlier literature. More recently, Kitao (2014) and Hosseini and Shourideh (2019) consider various policy options for creating sustainable social security systems in the face of demographic change and consider their associated effects on savings and capital formation. In contrast to these studies, we model the details of an actual pension reform. The Swedish pension reform has been studied in several contexts. Laun and Wallenius (2015) analyze its effect on labor supply in a life-cycle model similar to ours. Our contribution is that we explicitly model the transition between the old and the new Swedish pension system and that we analyze the effect of the reform on savings.

In Section 2, we describe the pension reform in detail. Sections 3-5 describe the model, the model experiment and the model calibration. Sections 6-7 describe the results from the model experiment. Sections 8-9 contain the sensitivity analysis and the discussion, and Section 10 concludes the paper.

2 The Swedish pension reform

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

2.1 Reform of public pensions in Sweden

Sweden is currently implementing a reform of its public pension system, with the main objective of improving the financial sustainability of the system. The first benefits from the new public system were paid out in 2001, but due to the gradual phasing-in of the reform, the new system will not be fully implemented until around 2050.

The reform of the public system 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 in all three dimensions as described by Lindbeck and Persson (2003). The general taxonomy of pension systems by Lindbeck and Persson (2003) is presented in Appendix 10.2.

2.1.1 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:

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

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.

2.1.2 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

[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 2020, the base amount is 47 300 SEK and the income-related base amount, which adjusts for income growth, is 66 800 SEK.

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

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. The accumulated pension rights in the PAYGO scheme are divided by an annuity divisor that mainly reflects the remaining average life span for the relevant age cohort at the time of retirement given current data. The balance in the funded pension account is divided by an annuity divisor that instead reflects expected future life spans.

There is gradual phase-in of the new public pension system. 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 pension from the old system and 4/20 from the new system, those born in 1939 obtain 15/20 from the old system and 5/20 from the new system etcetera. The use of national buffer funds, originally accumulated to support the financial sustainability of the old public system, facilitated the transition between the two systems.[8]

2.1.3 Minimum guaranteed pensions

In 2001, a minimum guarantee was introduced in place of the basic allowance and the special supplement in the old system. The minimum guarantee tops up public pensions to at least 2.3 base amounts.[9] 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.

2.2 Reform of the occupational pensions in Sweden

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, and two schemes in the public sector, one for central government and one for local government employees. The occupational pension schemes have undergone a reform in the same direction as the public pension system. There have been shifts from defined benefit to defined contribution schemes. Similarly to the reform of public pensions, the changes to occupational pensions are being phased in gradually, although the timing differs.

[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 contributions 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), by the time of the reform in 1998, the amount in the buffer funds was equal to approximately 5 years' worth of 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.

[9] This is if the individual is unmarried; for married individuals, the minimum guaranteed pension is 1.9 base amounts.

2.2.1 Reform of 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 yearly incomes 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:

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

Benefits are paid out for the remainder of the individual's life. The pre-reform 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.[10] The individual chooses whether to invest contributions in funds or in a traditional pension insurance with guaranteed interest. Contributions are made from the age of 25. Benefits are typically paid out for the remainder of the individual's life or can be withdrawn early, over a minimum period of five years. The post-reform scheme is financed through a premium reserve system, which means that the 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.[11]

2.2.2 Reform of 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,

[10] These percentages have increased over the years. The initial contribution in 2006 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 6.0 to 30 percent.

[11] We have not been able to find the details of these transition rules using online sources and published articles/reports.

65 percent of the income in excess of 7.5 and up to 20 (income-related) base amounts and 32.5 percent of the income in excess of 20 and up to 30 (income-related) base amounts. Benefits are typically paid out for the remainder of the individual's life or can be withdrawn early, over a minimum period of five years. The scheme is financed through a premium reserve system where pension benefits are paid out from invested assets.

Furthermore, there is a supplementary defined contribution part (*ITPK*), in which the pension contribution is 2 percent of the individual's income from the age of 28. The individual chooses whether to invest these contributions in funds or in a traditional pension insurance with guaranteed interest. Benefits from this supplementary scheme are typically paid out for the remainder of the individual's life or can be withdrawn early, over a minimum period of two years.

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. Contributions are made from the age of 25. Benefits are typically paid out for the remainder of the individual's life or can be withdrawn early, over a minimum period of five years. The scheme continues to be 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. This means that the post-reform scheme will not come into full effect until the cohort born in 1978 retires.

3 Model

We augment a standard life-cycle overlapping generations model of a small open economy with a detailed description of the pension system. There are three types of agents in the model; individuals that are either blue-collar ($\mathcal{T} = \mathcal{B}$) or white-collar ($\mathcal{T} = \mathcal{W}$) workers and a pension provider that manages the public and occupational pension schemes. Individuals enter the model at age T_0, die with certainty after age T_0+T and retire with certainty at age T_0+T_{ret}. The conditional probability of surviving between age t and $t+1$ is $\phi_{t+1} \in [0,1]$ and hence, the unconditional probability of surviving until time $t+1$ is $\Phi_{t+1} = \prod_{k=1}^{t} \phi_t$. Markets are incomplete in the sense that, except for the various pension assets described below, individuals only invest in a risk-free and liquid asset with the 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.

3.1 Labor income

Labor income $Y_t^{\mathcal{T}}$ for each type $\mathcal{T} \in \{\mathcal{B}, \mathcal{W}\}$ has a permanent component $P^{\mathcal{T}}$ and a transitory component V_t:

$$Y_t^{\mathcal{T}} = P_t^{\mathcal{T}} V_t \tag{1}$$

which follow the laws of motion

$$\log V_t = \nu_t \tag{2}$$

$$\log P_{t+1}^{\mathcal{T}} = \log G_{t+1}^{\mathcal{T}} + \rho_P \log P_t^{\mathcal{T}} + \eta_{t+1}. \tag{3}$$

where $G_t^{\mathcal{T}}$ is a deterministic age-component which captures the hump-shaped life-cycle profile observed in the data and ρ_P is the degree of persistence, calibrated to 1. ν_t and η_t are shocks such that e^{ν_t} and e^{η_t} are independently and identically lognormally distributed.[12]

$$e^{\nu_t} \sim \ln N(-\sigma_\nu^2/2, \sigma_\nu^2) \tag{4}$$

$$e^{\eta_t} \sim \ln N(-\sigma_\eta^2/2, \sigma_\eta^2) \tag{5}$$

3.2 Preferences

Individuals maximize the current and future expected utility from consumption by adopting an optimal savings plan. Future expected utility is discounted using discount factor β. Instant utility takes the form of a CRRA utility function with a constant intertemporal elasticity of substitution equal to $1/\gamma$

$$U_t(C_t) = \begin{cases} \frac{C_t^{1-\gamma}}{1-\gamma} & \text{if } \gamma > 0 \text{ and } \gamma \neq 1 \\ \log C_t & \text{if } \gamma = 1 \end{cases} \tag{6}$$

where C_t denotes consumption in age t.

3.3 Individual problem in old pension system

In the old public system, individuals earn pension points during their working life which determine the level of pension income in retirement. PP_t denotes pension points collected at age t and are given by labor income in excess of one base amount but lower than a ceiling $\overline{Y}$. Working-age individuals contribute a fraction λ^{pub} of their labor income to the public PAYGO scheme. In the occupational pension system, individuals pay type-specific contribution rates $\lambda_t^{\mathcal{B},occ}$ and $\lambda_t^{\mathcal{W},occ}$. The $Y_t^{\mathcal{B},net}$ is the labor income net of pension contributions and benefits. Futher details on how we model net income in working life are found in Appendix 10.3 and further details on how we model it in retirement are found in Appendix 10.4.

[12] Assuming that the first parameter equals $-\sigma_\nu^2/2$ and $-\sigma_\eta^2/2$ ensures that $E[e^{\nu_t}] = E[e^{\eta_t}] = 1$.

Blue-collar workers of age $t \in [1, T]$ solve the following problem

$$
\begin{aligned}
V_t^{\mathcal{B}}(P_t, A_{t-1}, \overline{PP}_t^m) = & \max_{C_t, A_t} \quad U_t(C_t) + \beta \phi_{t+1} \mathbb{E}_t \left[V_{t+1}^{\mathcal{B}}(P_{t+1}, A_t, \overline{PP}_{t+1}^m) \right] \\
\text{s.t.} \quad A_t + C_t = & (1+r)A_{t-1} + Y_t^{\mathcal{B},net} \\
PP_t = & \max\{0, \min\{\overline{Y} - 1, Y_t^{\mathcal{B}} - 1\}\} \quad \text{if } t < T_{ret} \\
\overline{PP}_{t+1}^m = & \begin{cases} \frac{1}{t+1}(PP_{t+1} + t \times \overline{PP}_t^m) & \text{if } t+1 \leq m \\ \overline{PP}_t^m + \max\{0, \frac{PP_{t+1} - \overline{PP}_t^m}{m}\} & \text{otherwise} \end{cases} \\
A_t \geq & 0, \quad A_0 = 0
\end{aligned}
\tag{7}
$$

where P_t is the permanent income component. A_t denotes total liquid assets and initial financial wealth A_0 equals zero. $\overline{PP}^m$ is an imperfect measure of the average pension points earned during the best m years.[13]

For white-collar workers, the problem is the same as the one above, except for labor income $Y_t^{\mathcal{W}}$ and net labor income $Y_t^{\mathcal{W},net}$ as well as the additional law of motion

$$
W_{t+1}^f = (1+r)W_t^f + \lambda^{f,\mathcal{W}} Y_{t+1}^{\mathcal{W}} \tag{8}
$$

where W^f is the illiquid funded pension account corresponding to the *ITPK* account. Workers are mandated to save a share ($\lambda^{f,\mathcal{W}}$) of their labor income in this account.

3.4 Individual problem in the new pension system

In the new pension system, individuals contribute a fraction λ^p of their labor income to the public PAYGO scheme up to the income ceiling $\overline{Y}$. When an individual contributes $\lambda^p Y_t^{\mathcal{T}}$ to the PAYGO scheme, the pension provider notes that this individual should be compensated by the same amount plus a compounded rate of return g during retirement. The balance on this notional PAYGO account is denoted W^p.

Individuals do also mandatorily pay contributions to the PPM and occupational schemes in a funded pension account denoted by W^f. This account has the same rate of return as the interest rate on liquid savings, r. On incomes below $\overline{Y}$, individuals mandatorily save $\lambda^f Y_t^{\mathcal{T}}$ in the funded account. On incomes above $\overline{Y}$, the mandatory savings rate into this account is instead $\overline{\lambda}^f \geq \lambda^f$. In addition to contributing to the funded scheme, individuals pay a pension tax which is used to fund the minimum guaranteed pension.

[13] In reality, the pension points are converted into pension income by setting the pension income equal to the average pension points from the m best income years. However, modeling this rule requires a large state space since the whole sequence of a worker's labor income realizations needs to be considered. To reduce the state space, we follow French (2003) by assuming that a high earnings year replaces an average earnings year, as given by the law of motion for $\overline{PP}^m$. Since, in reality, a high-income year replaces a low-income year, this approximation will underestimate the pension points and hence, the measure is imperfect.

In the new system, blue-collar and white-collar workers face the same problem:

$$
\begin{aligned}
V_t^{\mathcal{T}}(P_t, A_{t-1}, W_t^p, W_t^f) = \max_{C_t, A_t} \quad & U_t(C_t) + \beta\phi_{t+1}\mathbb{E}_t\left[V_{t+1}^{\mathcal{T}}(P_{t+1}, A_t, W_{t+1}^p, W_{t+1}^f)\right] \\
\text{s.t.} \quad & A_t + C_t = (1+r)A_{t-1} + Y_t^{\mathcal{T},net} \\
& W_{t+1}^p = (1+g)W_t^p + \lambda^p \min\{\overline{Y}, Y_{t+1}^{\mathcal{T}}\} \\
& W_{t+1}^f = \begin{cases} (1+r)W_t^f + \lambda^f Y_{t+1}^{\mathcal{T}} & \text{if } Y_{t+1}^{\mathcal{T}} \leq \overline{Y} \\ \\ (1+r)W_t^f + \lambda^f \overline{Y} & \\ +\overline{\lambda}^f (Y_{t+1}^{\mathcal{T}} - \overline{Y}) & \text{otherwise} \end{cases} \\
& A_t \geq 0, \quad A_0 = 0
\end{aligned}
\tag{9}
$$

Further details on how we model the net labor income, $Y_t^{\mathcal{T},net}$, in working life and retirement are found in Appendix 10.3 and Appendix 10.4.

3.5 Pension provider

There is a pension provider which manages both public and occupational pension schemes. In the old pension system, the pension provider balances the public defined-benefit scheme by solving for the contribution rate, to ensure that payments into the system equal payments out of the system. In the old occupational defined-benefit system, the pension provider balances the budget within occupational groups, so that blue-collar (white-collar) workers fund occupational pensions for blue-collar (white-collar) retirees. In the new pension system, the tax rate needed to fund the minimum guaranteed pension income is found by solving a balanced budget condition over the entire population. The balanced budget conditions are explicitly defined in Appendix 10.5.

Note that the contribution rate to the public scheme (λ^p) is not time-dependent in the new system. The task of the pension provider is to choose an exogeneous rate of return g on the notional pension asset which balances the system. A deficit or surplus of the pension provider's budget can arise, unless the rate of return on the notional account (g) is appropriately adjusted, see section 4.2.3.[14]

4 Model experiment

4.1 Scenarios

We simulate several different scenarios. First, we consider three scenarios where the population growth is constant and all individuals are completely in either the old or the new pension system.

[14] g can be modeled as an endogenous outcome of the model by similarly solving a balanced budget condition. The rate of return would then depend on the total labor income among the working age population relative to the total claims of the retired population.

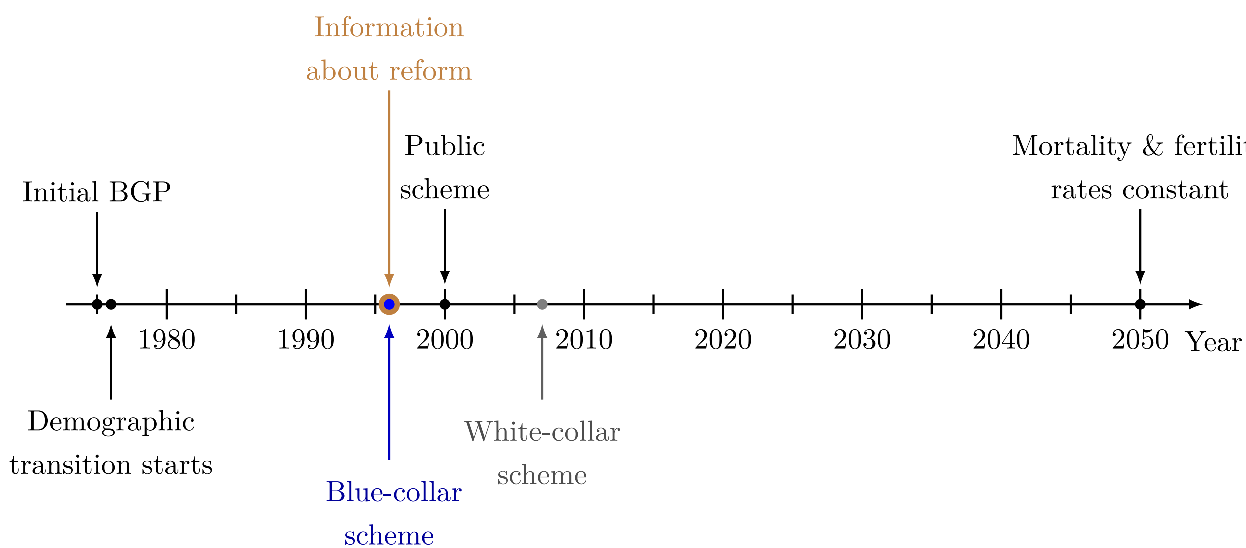
Since the model permits a positive population growth, the aggregate variables will grow at constant rates. Hence, we refer to these scenarios as *balanced growth paths*. The scenarios are:

1. an initial scenario prior to demographic transition and the pension reform,
2. a future scenario after demographic transition and the pension reform, and
3. a future scenario after demographic transition but without the pension reform (counterfactual scenario).

Second, we consider income and savings dynamics during the transition between the initial scenario and the future scenario with demographic transition and the pension reform. We set the announcement year for all policy changes to 1996 in the model.[15] The results for this transition are compared to a transition from the initial scenario to a future counterfactual scenario without the pension reform. The timing of events is described in Figure 2 below.

[15]The different parts of the reform were announced on different dates, see Section 2.

Figure 2: Timing of events in a model with demographic transition and pension reform



Notes: The economy is on a balanced growth path (BGP) in 1975 with constant mortality and fertility rates. In 1976, all agents understand that the mortality and fertility rates will fall over time. In 1996, agents are informed about the gradual phasing-in of the pension reform which will start at different points in time for different schemes. In particular: The phasing-in of the new blue-collar occupational scheme starts in 1996, the public scheme in 2000 and the white-collar occupational scheme in 2007. From the year 2050 and forward, the fertility and mortality rates for different ages are again constant at their new lower levels.

4.2 Transition

During the transition, we let the model go through both a gradual demographic change and a phasing-in of the new pension system. To this end, we need to keep track not only of an individual's age t but also of her year of birth b or, equivalently, the current year s. The news of demographic change comes as a surprise to individuals and the news of the pension reform comes as another surprise.

4.2.1 Demographic transition

We assume that the economy starts in a balanced growth equilibrium in year s_0 in which the old-age dependency ratio (ODR) is relatively low. Then, we let the mortality rate and the birth rate n_s vary across cohorts so that the ODR increases over time and eventually reaches a new stationary level. Individuals become aware of the path of future population growth in year s_0.

4.2.2 Transition between old and new pension system

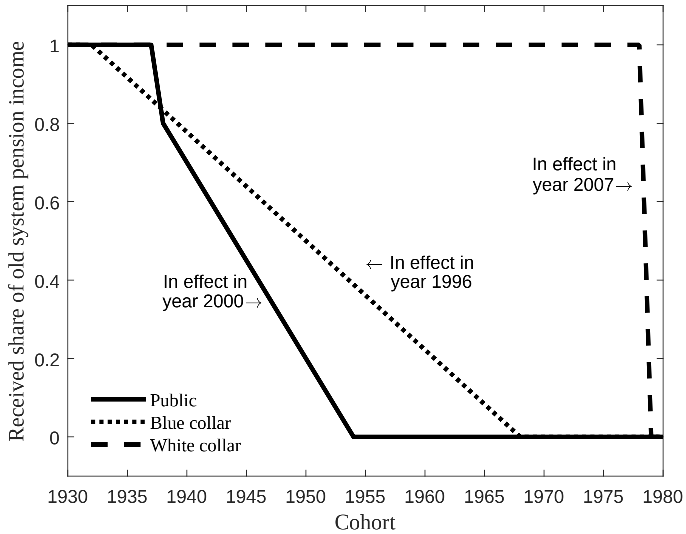
The new pension system is gradually phased in across cohorts to match the Swedish pension reform described in Section 2. During the transition, individuals born in year b get a share $1 - \alpha_b$ of the public pension income determined according to the rules in the old pension system (Y^{pub}) and a share α_b of public pension income determined according to the rules in the new system where $\underline{Y}^N$ denotes the minimum guaranteed pension and Y^p is the pension from the notional PAYGO account. Whereas the transition to the new public pension system is the same for all types of workers, the transitions to the new occupational systems are different for blue and white-collar workers, as shown in Figure 3. For blue-collar workers, we model a gradual phasing-in of the new defined contribution system for individuals born between 1937 and 1967. We also let the above-ceiling contribution rate to the blue-collar occupational system increase step-wise between 1996 and 2006.[16] For white-collar workers, the new occupational system applies to everyone born after 1978. Hence, The share of the occupational pension income determined according to the rules for income from the old occupational PAYGO system ($Y^{\mathcal{T},occ}$) is given by $1 - \alpha_b^{\mathcal{T}} \in [0, 1]$. Hence, an individual i born in year b receives the pension income

$$(1 - \alpha_b)Y^{pub} + \alpha_b \max\{\underline{Y}^N, Y^p\} + (1 - \alpha_b^{\mathcal{T}})Y^{\mathcal{T},occ} + Y^f \tag{10}$$

where $1 - \alpha_b \in [0, 1]$. All occupational pension income in the new system is fully funded and hence contained in Y^f. There is no explicit transition rule for pension income from fully funded pension wealth, because such pension wealth is tied to the individual and hence, by definition, is not transferable between individuals.

[16] This stepwise implementation of a higher contribution rate on high incomes for blue-collar workers is in accordance with reality, where higher contributions were gradually phased-in for blue-collar workers (Hagen, 2013). We model the step-wise implementation as follows: Between 1996 and 2006, blue-collar workers do not pay higher contributions on incomes above the ceiling. They contribute $\lambda^f = 0.07$ below the ceiling and only $\bar{\lambda}^f = 0.045$ above. After 2006, they instead contribute $\bar{\lambda}^f = 0.30$ above the ceiling.

Figure 3: Transition rules for different cohorts and types of workers



Notes: During the transition, retirees in cohort b get the share α_b of the pension income determined according to the rules in the new pension system, plus the share $1-\alpha_b$ of the pension income determined according to the rules in the old pension system. The graph illustrates how the transition is implemented in the model, which is the same as in reality for the public scheme and the white-collar scheme. We know that, in reality, the cohorts born between 1932 and 1966 are the transition cohorts in the blue-collar scheme, but we have not found any information on exactly how the new blue-collar scheme has been phased-in for blue-collar workers.

4.2.3 Budget balancing during the transition

Since the return g on the notional public pension asset is an exogenous parameter, surpluses or deficits can occur in the new public pension system. In reality, the financial buffer fund of the public pension system can step in to cushion temporary differences between pension contributions and pension benefits. Since 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 the sum of total net 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 the income.

Similar balancing issues occur in the transition from the old to the new occupational pension systems. In reality, these balancing issues are handled by employers and therefore, we do not impose budget balancing on the pension systems during transition years. Instead, our modeling ensures that all individuals pay contributions and get benefits in accordance with the transitional rules while there appear surpluses or deficits in the pension systems. Moreover, we let cohorts that receive occupational pension benefits entirely according to the old pension system continue to pay contributions in line with the contribution rate they would have paid in the counterfactual scenario without the pension reform.

5 Calibration

5.1 Labor income

We take the exogenous deterministic age-dependent component of the income-profile, $G_t^{\mathcal{T}}$, from Laun and Wallenius (2015). Our blue-collar and white-collar workers are averages of their two profiles for the respective worker category. We do not explicitly model other taxes and transfers but make the simplifying assumption that these are proportional to income. Incomes are expressed in base amounts as described in Section 2.

Idiosyncratic labor income shock processes for Swedish individuals are obtained from Domeij and Floden (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.

5.2 Demographics

The starting year of our analysis is 1975. We calibrate the initial birth rate to match the Swedish old-age dependency ratio (ODR) in 1975 of about 25. The final birth rate is calibrated to match the projected ODR in 2075 (OECD, 2017) of 0.50. The birth rates of cohorts entering the labor market during the demographic transition are given by a linearly spaced interpolation between the initial net birth rate of 0.7% and the final birth rate of 0.5%. The ODR path is depicted in Figure 12. In the model, the mortality probability at age t is $(1 - \phi_t)$. Exogenous mortality probabilities (actual and projected) are obtained from Statistics Sweden.

5.3 Exogenous parameters

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 the notional PAYGO account in the new pension system (g) is also set to 2 percent, reflecting the real wage growth in Sweden. The share of white-collar workers in the labor-force is calibrated to 43 percent, reflecting the share of 25-64 year-olds with a college education in Sweden in 2018.

All parameters relevant for the pension system are chosen according to the Swedish old and new pension systems described in Section 2. The discount rate and the elasticity of intertemporal substitution are set to standard values from the literature. A summary of exogenous parameters follows in Table 1.

Table 1: Exogenous parameters

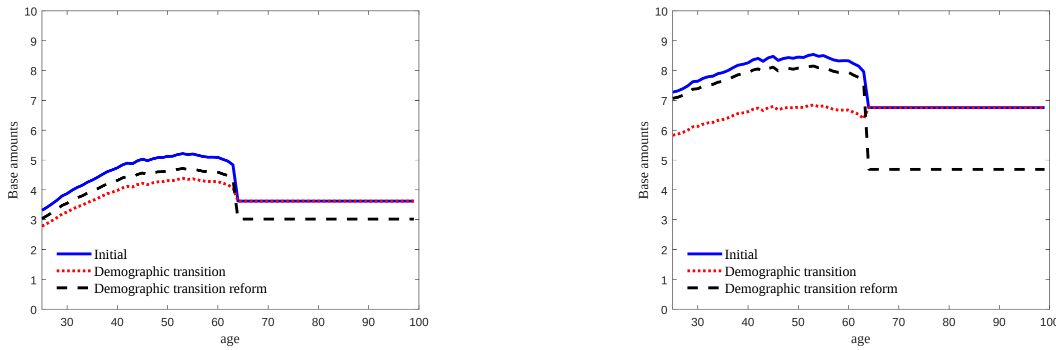
Parameter	Description	Value
T_0	Age when individuals enter the model	25
T	Maximum years alive after age T_0	75
T_{ret}	Years until retirement at age T_0	40
$1/\gamma$	Elasticity of intertemporal substitution	1/2
β	Discount factor	0.97
r	Interest rate	0.02
g	Rate of return on NDC PAYGO wealth, new public scheme	0.02
λ^p	Contr. rate, new public scheme	0.16
λ^f	Contr. rate on income up to $\overline{Y}$, new funded scheme	0.07
$\overline{\lambda}^f$	Contr. rate on income above $\overline{Y}$, new funded scheme	0.30
ρ_P	Degree of persistence in earnings	1
σ_η^2	Variance of persistent earnings shock	0.0169
σ_ζ^2	Variance of idiosyncratic earnings shock	0.0584
ρ	Repl. rate on average pension points, old public scheme	0.60
$\rho^{\mathcal{B}}$	Repl. rate, old blue-collar occ. scheme	0.1
$\rho_1^{\mathcal{W}}$	Repl. rate on income up to $\overline{Y}$, old white-collar occ.	0.1
$\rho_2^{\mathcal{W}}$	Repl. rate on income between $\overline{Y}$ and $\overline{Y}_2^{\mathcal{W}}$, old white-collar occ.	0.65
$\rho_3^{\mathcal{W}}$	Repl. rate on income between $\overline{Y}_2^{\mathcal{W}}$ and $\overline{Y}_3^{\mathcal{W}}$, old white-collar occ.	0.325
m	No. of highest income years, old public system	15
$\overline{Y}$	Income ceiling for contributions & repl. rates	7.5
$\overline{Y}_2^{\mathcal{W}}$	Second income ceiling for repl. rates	20
$\overline{Y}_3^{\mathcal{W}}$	Third income ceiling for repl. rates	30
$\underline{Y}^O$	Guaranteed minimum pension income, old system	0.96
$\underline{Y}^N$	Guaranteed minimum pension income, new system	2
λ^{itpk}	Contr. rate, old funded white-collar occ. scheme	0.02
θ	Share of blue-collar workers	0.57

6 Results on a balanced growth path

6.1 Contribution rates

In our counterfactual scenario without the pension reform, individuals' pension benefits relative to labor income are constant, as per the rules in the old pension system. To maintain constant pension benefits in a period of increasing life expectancy but unchanged retirement age, the contribution rates of working-age individuals have to increase to finance pensions to the currently old. Without the pension reform, the contribution rates reach 35 per cent for blue-collar workers and almost 45 percent for white-collar workers, see Figure 13. Although it is theoretically possible to run a balanced PAYGO system under the old regime, it results in unprecedingly high contribution rates which illustrates the reason for the pension reform.

Figure 4: Average net labor income



(a) blue-collar workers

(b) white-collar workers

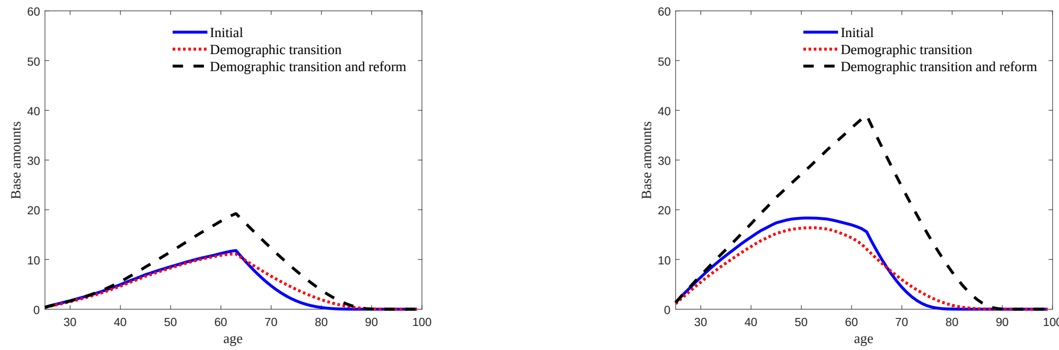
Notes: Average net labor income on a balanced growth path under three scenarios.

6.2 Income under old and new pension system

Figure 4 shows average net labor income on a balanced growth path under the three scenarios. The initial scenario, without demographic transition, and the counterfactual scenario without the pension reform imply the same pension levels but very different levels of net labor income in working life. Without the reform, the high contribution rates imply that the differences in net income between working age and retirement become small. In fact, blue-collar workers would, on average, get a slightly higher income in retirement than in early working life. In contrast, the pension reform redistributes labor income from retirement to working age which implies lower replacement rates relative to final net labor income. With the reform, the average replacement rate falls from 75 percent to 69 percent for blue-collar workers and from 84 percent to 61 percent for white-collar workers as compared to the initial scenario. Hence, the reform gives workers, especially white-collar workers, a stronger incentive to accumulate savings in working life so as to smooth the consumption over the life-cycle. How the different parts of the pension reform contribute to these results is described in Appendix 10.7.

The pension reform has important implications for the distribution of pension income. Among blue-collar workers, the majority get lower pensions in the new system as compared to the old system. However, the lowest pension income is raised by the new minimum guaranteed pension and there is also a small number of blue-collar workers who get higher incomes in the new system due to higher occupational pensions. Among white-collar workers, there is a consistent shift of the pension distribution to the left. In the old system, individuals that have a very high last period income could enjoy a very high pension throughout their life. In the new system, pensions are based on the entire lifetime income so the distribution is more concentrated and the very high pensions observed under the old system are no longer found. The distributions of pension income are shown in Figure 14.

Figure 5: Average wealth



(a) blue-collar workers (b) white-collar workers

Notes: Average private liquid wealth on a balanced growth path in three scenarios.

6.3 Savings under old and new pension system

Figure 5 shows average accumulated private savings, that is wealth, on a balanced growth path under the three scenarios. The accumulated savings are relatively similar during early working age. Without the pension reform, the average white-collar worker starts to dis-save in her early 50s. The reason is that the motivation for precautionary savings decreases over time as the uncertainty over future income recedes. In fact, the smooth income profiles in the future counterfactual scenario without the pension reform indicate that there is little reason to save for retirement on average.

With the pension reform, individuals choose to accumulate more savings from their early 40's and onward. The average 60-year old blue-collar worker chooses to accumulate 60 percent more wealth as compared to the initial scenario.[17] The average 60-year old white-collar worker accumulates more than twice as much wealth as compared to the initial scenario.[18] It is clear that individuals save for retirement since they increase their accumulated savings until age 65 and thereafter dis-save. How the different parts of the pension reform contribute to savings is described in Appendix 10.8. The distribution of wealth is also markedly altered by the pension reform. In the initial scenario, almost 40 percent of blue-collar workers and more than 30 percent of white-collar workers go into retirement with very little wealth, less than one base amount. In the new system, these numbers are 27 and 9 percent, respectively, as both distributions shift to the right as seen in Figure 15.

The increase in wealth accumulation in the scenario with the pension reform implies that aggregate household wealth will be significantly higher as compared to the other scenarios.However, the level of aggregate wealth does not necessarily give a prediction for the aggregate savings rate on a balanced growth path. With the pension reform, the savings rate among working cohorts will

[17] 17 base amounts corresponding to SEK 1.1 million.

[18] 36 base amounts corresponding to SEK 2.3 million.

be higher but, when these individuals dis-save in retirement, their savings rate will turn strongly negative. On a balanced growth path when the (real) income is constant but the population is growing, the aggregate savings rate is only determined by the proportion of working age (savers) relative to retired (dis-savers) and the interest rate on savings. In general, determining the impact of the pension reform on aggregate savings in a given year requires adding up the changes induced in the savings behavior of all individuals alive in that year. We next turn to the development of the aggregate savings rate over time.

7 Results in transition

7.1 Aggregate savings rates

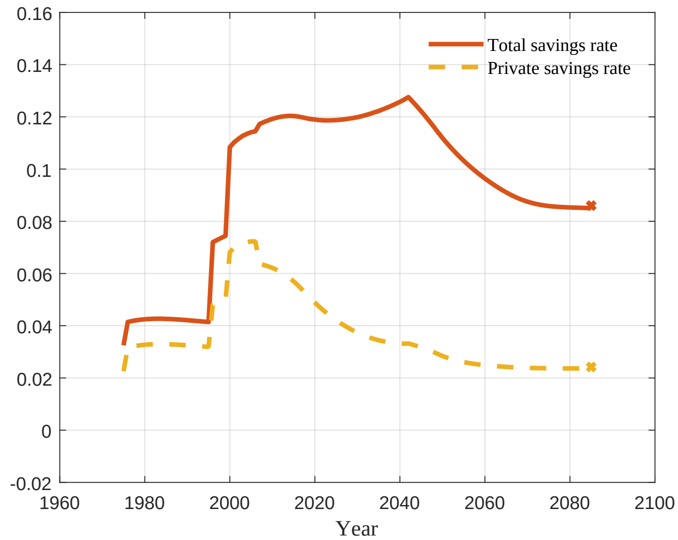
Figure 6 shows the aggregate savings rates in a scenario with a pension reform with savings rates calculated according to the definitions described in Appendix 10.1. Before 1975, the aggregate savings rate is constant and determined by the population growth and the interest rate prevailing on the initial balanced growth path. In 1975, the private savings rate increases as individuals learn about demographic change and start planning for a longer life. As a consequence, the total savings rate, which reflects the private savings rate and mandatory funded pension savings, increases.

There is a significant increase in the savings rates due to the pension reform. The private savings rate jumps first at the reform announcement in 1996 and later at the implementation of the public pension reform in the year 2000. Since retirees are unaffected by the reform, the increases in the savings rate are due to increased savings by working-age cohorts. In total, the private savings rate increases by 4 percentage points between the pre-announcement year 1995 and the post-reform peak in 2006. The total savings rate jumps in 1996, partly because of the increase in private savings and partly because of the introduction of the fully funded scheme for blue-collar workers. Similarly, the increase in the total savings rate by 3 percentage points in the year 2000 is partly due to the increase in private savings but mostly due to the introduction of the fully funded public PPM-system. Overall, the total savings rate increases by 8 percentage points between the pre-announcement year 1995 and the year 2018.

To further distinguish the effect of the pension reform from the effect of a change in demographics, Figure 7 shows the counterfactual savings rate in case of no reform. Here, the total savings rate coincides with the private savings rate, with the exception of the fully funded ITPK-account in the old white-collar occupational pension system. Similar to above, the savings rates increase in 1975 as individuals start planning for a longer life. However, this pattern is reversed as the population growth slows down and working age savers become fewer relative to retired dissavers. In fact, the private savings rate is unchanged between the pre-announcement year 1995 and the year 2006. Thus, we can conclude that the entire increase in the private savings rate between 1996 and 2006 is due to the pension reform and not to demographic changes.

According to aggregate data, the private savings rate and the total savings rate have increased by

Figure 6: Aggregate household savings rate with reform



Notes: Savings rates according to the definitions in Appendix 10.1. The savings rates on the future balanced growth path are marked by crosses.

8 and 10 percentage points, respectively, between 1995 and 2018; see Figure 1. Hence, our model can explain about one half of the increase in the private savings rate and about 80 percent of the increase in the total savings rate.[19] However, our model shows a discrete drop in the private savings rate in 2007 when white-collar workers, born after 1978 and subject to the new occupational rules, enter the labor market. After that, there is a gradual decline in the private savings rate until the full phase in of the new white-collar occupational system in 2078. Hence, our model does not succeed in matching the continuous increase in the private savings rates until the present day. The total savings rate increases until white-collar workers in the new fully funded occupational scheme retire and start dissaving around 2040. In the long run, the reform results in a much higher total savings rate compared to the initial scenario.[20]

7.2 What explains the aggregate savings rate in the transition?

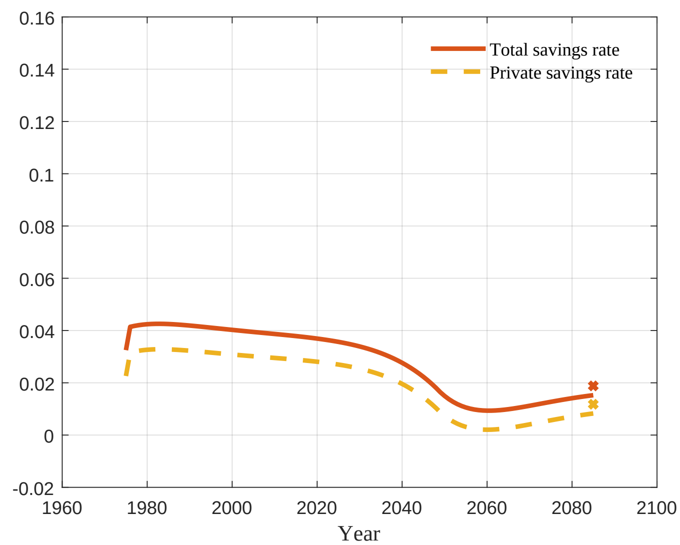
7.2.1 Income of transitional cohorts

Cohorts that are affected by the transitional rules partly benefit from the lower contribution rates but also receive the lower pensions of the new system. Figure 8 shows the average net labor income

[19] If we instead make a comparison to the trough savings rate in the year 2000, our model can explain more than one quarter of the increase in the private savings rate and about half of the increase in the total savings rate.

[20] After the year 2078, all individuals in our model receive pension according to the rules of the new system. However, their pension contributions, income and savings decisions are still affected by the transition from the old to the new pension system. Not until the year 2120 will the model reach a new balanced growth path on which the savings rate reflects the new lower population growth.

Figure 7: Aggregate household savings rate without the reform

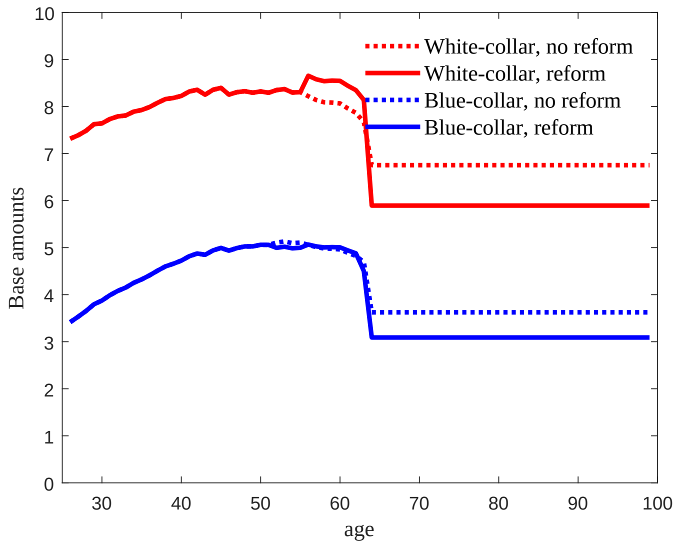


Savings rate according to the definitions in Appendix 10.1. The savings rates on the future balanced growth path are marked by crosses.

over the life-cycle for individuals born in 1944 in the scenarios with and without the pension reform. According to the transitional rules, this cohort receives 50 percent of the public pensions from the new system and the remainder from the old system. Among white-collar workers, the average net labor income jumps at the age 56 as a result of the lower contribution rates entering into force in the year 2000. However, the increase in income during working life is small and short-lived relative to the drop in income during retirement. White-collar workers get on average 13 percent lower pensions as compared to what they would have had if they had remained fully in the old system. The average working age net labor income of blue-collar workers is only marginally affected by the gradual phase-in of the public pension reform and the blue-collar occupational reform implemented in 1996 (at age 52). However, they do, on average, get 15 percent lower pensions as compared to what they would have had in the counterfactual scenario without the pension reform. We can draw two conclusions. First, the reform results in lower replacement rates which creates an increased incentive to accumulate savings for retirement. Second, when the reform occurs late in life, lower contribution rates do, on average, not 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.

The implementation of the occupational pension schemes also plays a role for the life-cycle income profiles. The new white-collar occupational system implies that individuals born in 1979 on average pay slightly higher contributions but receive lower pensions as compared to individuals born in 1978. The net effect is a lower replacement rate for the cohort born in 1979 and a stronger motive to accumulate savings for retirement to smooth life-time consumption. Among blue-collar workers, our model results in higher pensions for individuals that are more exposed to the new blue-collar

Figure 8: Average net labor income for cohort born in 1944



Notes: Scenario with demographic transition only and no pension reform (dashed lines) and scenario with demographic transition and pension reform (solid line). The cohort born in 1944 gets 50 percent of its pension income from the new system and the remainder from the old system.

occupation system as seen in Figure 16.

The resulting labor income profiles from our model can be compared to the actual labor income in the data. Table 2 displays replacement rates for the cohort born in 1951 resulting from the model compared to actual replacement rates reported by Pensionsmyndigheten (2019). It shows that the model results are very similar to the actual data. The average replacement rate resulting from the model (0.92) is almost exactly the same as the average replacement rate measured in the data (0.93) and the median is also close (0.74 compared to 0.79). However, the model generates a somewhat larger fraction of very low and very high replacement rates as compared to the empirical measures.

7.2.2 Savings of transitional cohorts

When the pension reform is announced, most of the workforce has spent a substantial part of their working life believing that they would receive public pension benefits based on the old system. In 1996, individuals between 42 and 58 years of age learn that they will get part of the pension according to the new rules and individuals below age 42 learn that they will get their entire pension from the new system. Hence, many individuals find themselves in a situation where they have accumulated lower retirement savings than desired.

Figure 9 shows the savings rate for the cohort born in 1944. These individuals have spent half of their working-life expecting public pensions according to the old system. The reform announcement

Table 2: Comparison of replacement rates

Percentile	Data	Model
Mean	0.93	0.92
p10	0.50	0.41
p25	0.64	0.56
Median	0.79	0.74
p75	1.1	1.07
p90	1.34	1.60

Notes: The replacement rate refers to pension income at age 65 relative to the average labor income during five years before retirement. Individuals born in 1951.

occurring at age 52 leads to a higher savings rate among blue-collar workers compared to the counterfactual scenario. Among white-collar workers, the announcement only leads to a slightly higher savings rate. Instead, white-collar workers increase their savings rate at the time of the implementation of the reform when contribution rates fall and disposable income increases. To smooth life-time income, it is rational to save more when income is high. These higher savings rates constitute the reason for the increase in the aggregate savings rate at the reform announcement and implementation. However, a higher savings rate in working life translates into a lower savings rate in retirement. The dissavings of transitional cohorts is a force contributing to a lower aggregate savings rate from 2003 and onwards.

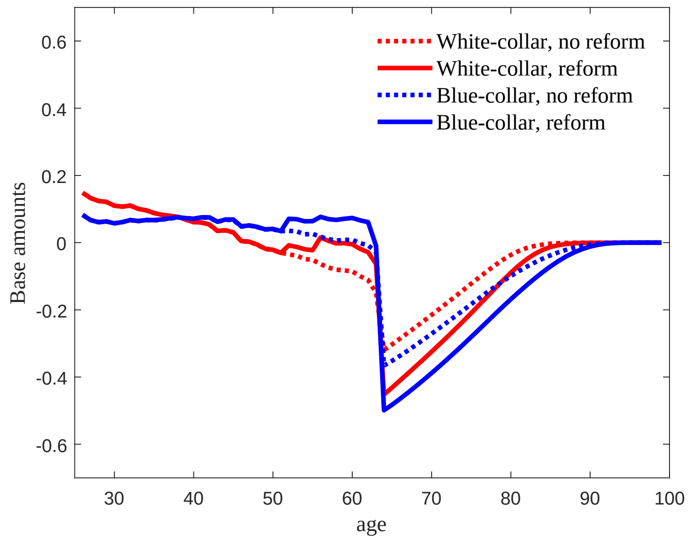
The occupational reforms also affect the savings behavior. Despite the fact that white-collar workers get a lower replacement rate in the new pension system, the cohort born in 1979 on average accumulates less savings than the cohort born in 1978 as seen from Figure 10. The reason for this behavior is the different risk profile of the two pension systems. In the new system, occupational pensions are based on the entire stream of lifetime contributions. This means that, at each point in time, individuals know the minimum occupational pension they will get based on the pension contributions paid so far. As individuals get older they can make increasingly accurate forecasts of their future pension.[21] In contrast, under the old system, occupational pensions are based on the income in the last year of working life which means that it is more difficult to forecast the future occupational pension income. In particular, even if an individual has so far had a high labor income, there is still a risk of being hit by a bad shock in the last period and get a very low occupational pension. To insure against this risk, all else equal, individuals in the old pension system accumulate more savings compared to their peers in the new system.[22] The lower savings rate of individuals in the new white-collar occupational pension system is the major reason behind the drop in the aggregate savings rate in the year 2007.

The savings rates at the micro-level resulting from the model can be compared to actual savings rates in the data. Table 3 shows a comparison of the savings rates of all Swedish individuals between

[21]This is particularly the case as there is no financial market risk in the model.

[22]If we turn off income shocks in the model, individuals born in 1979 save more than individuals born in 1978.

Figure 9: Average private savings rate for cohort born in 1944



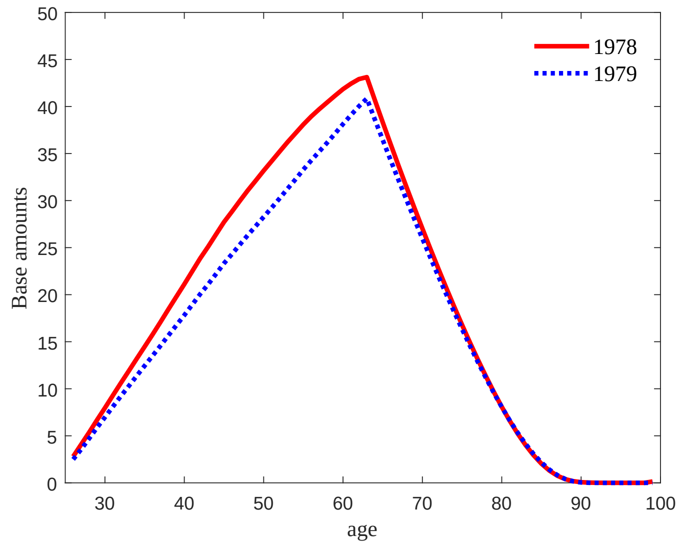
Notes: Private savings rate according to the definition in Appendix 10.1. Scenario with demographic transition only and no pension reform (dashed lines) and scenario with demographic transition and pension reform (solid line). The cohort born in 1944 gets 50 percent of its pension income from the new system and the remainder from the old system.

the years 2000 and 2007 when individuals are ranked along the wealth distribution. The savings rate definitions and the empirical savings rates are as reported by Bach et al. (2017). The model results are qualitatively similar to the data. The active savings rate is falling along the wealth distribution which reflects the fact that as individuals become richer they do not only consume their labor income but also part of their capital income. The total savings rate is increasing along the wealth distribution reflecting the fact that richer individuals overall have higher savings rates. However, in terms of magnitude, the model does not fit the data very well, especially among the wealthier individuals. For example, according to the model, the average active savings rate of the 80th-90th percentiles is -8 percent while according to the data it is -28 percent. One conjecture is that this discrepancy reflects the fact that different individuals have different returns on their financial assets. The empirical evidence points to the fact that wealthier individuals earn higher returns which affect capital income and savings behavior (Bach et al. 2016).

8 Sensitivity analysis

In this section, we investigate the robustness of the model with respect to changes in parameter values. We focus on the main result that the aggregate private savings rate increases by 4 percentage points due to the pension reform as compared to the counterfactual scenario. Overall, we find that this result is robust to changing parameter values.

Figure 10: Average private wealth for white-collar workers born in 1978 and 1979



Notes: The cohort born in 1978 is entirely in the old occupational pension system. The cohort born in 1979 is entirely in the new occupational pension system.

Changing the composition of worker types. A higher aggregate savings rate is mainly driven by the behavior of white-collar workers. There are 43 percent white-collar workers in our baseline calibration which represents an increase from 30 percent in the year 2000. Decreasing the share of white-collar workers in our model from 43 to 30 percent leads to a slightly lower savings rate but does not alter our main result.

Changing the announcement year. We assume that the announcement of the reform coincides with the start of the implementation of the new blue-collar occupational scheme in 1996, see Figure 2. We check for robustness to the announcement date by changing the year of policy changes from 1996 to 1990, as well as from 1996 to 2000. These changes move the jump in the private savings rate back and forth in time but do not significantly alter our main result.

Changing the intertemporal elasticity of substitution. The intertemporal elasticity of substitution (IES) is important for our results as it determines agents' willingness to let their consumption vary over time. A lower IES means that agents are less willing to let their consumption vary and thus implies a larger buffer-stock savings motive. We have set the IES to 0.5 in our model, which is a standard calibration in quantitative life-cycle models and the mean reported estimate in a large survey of empirical estimates of the IES by Havranek et al. (2015). These empirical estimates vary considerably, however. Havranek et al. (2015) suggest that the IES for Sweden might be lower than 0.5. Reducing the IES in our model from 0.5 to 0.33 gives nearly a one percentage point higher peak aggregate savings rate as compared to the main result.

Changing the interest rate. In the standard life-cycle setting, a higher interest rate makes

Table 3: Comparison of savings rates (percent)

	Data		Model	
Percentile	Active sr	Total sr	Active sr	Total sr
p10-p20	3.9	2.4	-5.2	-3.2
p20-p30	11.6	13.6	-4.6	-1.0
p30-p40	9.6	16.2	-4.7	0.0
p40-p50	7.9	18.3	-5.7	0.0
p50-p60	4.2	18.7	-7.7	0.4
p60-p70	-2.5	18.8	-8.6	1.3
p70-p80	-12.2	19.9	-8.6	2.4
p80-p90	-28.4	23.4	-8.4	3.4

Notes: Savings rates of all Swedish individuals between 2000 and 2007. The active savings rate corresponds to savings out of labor income in relation to labor income. The total savings rate corresponds to savings out of total income (capital and labor income) in relation to total income. Empirical savings rates from Table II in Bach et al. (2017). Percentiles in terms of wealth distribution.

savings more attractive relative to consumption, which implies a larger savings motive (the substitution effect). At the same time, a higher interest rate increases the income from savings which makes agents better off, implying larger consumption and a smaller savings motive (the income effect). We test for robustness by changing the interest rate from 2 percent to 1 percent and 3 percent, respectively. Changing the interest rate affects the aggregate savings rate in scenarios both with and without the pension reform: With a higher interest rate, the aggregate savings rate is higher. The difference between the increase in the aggregate savings rate due to the pension reform compared to the counterfactual scenario is, however, unaffected, meaning that our main result is unaffected. We can also conclude that the substitution effect dominates the income effect in our model.[23]

Changing income shocks during working life. The size of income shocks during working life is important for our results as a less variable income during working life means that agents' buffer-stock savings motive is smaller. In particular, the larger the income shocks, the greater is the uncertainty in the old occupational pension system, where pension income depends on a few time periods late in life. Overall, reducing the variance of permanent and transitory income shocks by half implies a one percentage point lower peak aggregate savings rate compared to the main result.

9 Discussion

For the purpose of our analysis, we make a number of simplifying assumptions. First, we assume that agents are forward-looking and rational. Specifically, agents choose consumption and savings

[23]The strength of the substitution effect depends on the IES, the discount factor, and the probability of survival, as well as the interest rate.

in each period to maximize their expected discounted lifetime utility. This is a standard assumption in quantitative life-cycle models and widely used in the related literature, for example in Laun and Wallenius (2015). However, it is an idealization of reality.[24]

Second, we assume that the reform announcement was unanticipated, i.e. that agents had no knowledge of the pension reform prior to its announcement. For simplicity, we set the announcement year for all policy changes to 1996 in the model, although the actual reform consists of policy changes that were announced and implemented at different times. The model could be made more realistic by modeling the announcement of each part of the reform separately. The fact that the actual savings rates have increased more slowly than in the model may indicate that learning about the reform was gradual.

Third, we assume that agents make their consumption-savings choices having full-time private sector employment and a fixed retirement age. We do not investigate the labor supply responses of the Swedish pension reform, as has been done by Laun and Wallenius (2015).[25] Full-time employment is the norm in the Swedish private sector, which comprises 70 percent of the labor force. The average retirement age has remained constant at 65 in Sweden over the last few decades although an increasing number of people retire earlier and later. Recently, there have been regulatory changes aimed at increasing the retirement age. Increasing the retirement age in our model, while keeping life expectancies constant, means that agents will spend a smaller share of their life in retirement, thus leading to a weaker life-cycle savings motive.

Fourth, we assume that agents cannot borrow; they can only accumulate and de-cumulate savings. This is reasonable in our model since individuals typically cannot borrow using accumulated pension wealth as the collateral and non-collateralized borrowing is limited in Sweden. A model including housing should also feature mortgage debt which represents the bulk of household debt in Sweden. Allowing for borrowing would reduce the precautionary savings motive.

Fifth, we do not consider other possible explanations for an increased savings rate, such as other changes to social security, housing market developments or increased income inequality. There have been reforms in Sweden that reduced the benefit levels in disability and unemployment insurance and made the eligibility criteria for such insurance more stringent. Such reforms affect savings by strengthening individuals' buffer-stock savings motive.

In the Swedish context, rising house prices are generally considered to affect household savings decisions. It is worth noting that the savings rate is not affected by changes in the valuation of assets, regardless of whether those values are realized or not.[26] There are other housing-related

[24]There is a debate on whether individuals save adequately for retirement, and the literature has so far not settled on one view. Studies that support the assumption of rational behavior are e.g. Scholz et al. (2006) and Crawford and O'Dea (2020).

[25]As shown in Laun and Wallenius (2015), the reform of the public PAYGO system is likely to increase the labor supply and delay the age of retirement. However, their analysis does not include the increase in minimum guaranteed pensions which is likely to decrease labor supply in their model.

[26]For example, a sale of a house implies a transaction of a real asset for a financial asset and the net effect on

savings objectives, such as saving towards the downpayment for a house. When house prices rise faster than incomes, larger savings may be required to enter the housing market. This effect may be amplified by macroprudential regulations requiring higher downpayment and faster amortizations. Sweden has also seen an increased income inequality over the last decades, which likely affects the savings rate. This could be due to a growing share of wealthy people saving more, out of preference and/or because they access larger returns to savings. These factors may also help explain the increased aggregate savings rate.

10 Conclusion

In this paper, we evaluate the effect of a pension reform on household income and savings. We study the Swedish pension reform since it is a major example of a reform aimed at creating a financially stable pension system in the face of an ageing population. The reform results in a shift in income from retirement to working age which implies lower contribution rates among the working population. This shift creates an incentive to increase savings, especially among individuals that were affected by the reform late in life and had expected the high pension in the old system. We find that the reform is an important explanatory factor behind the observed increase in the savings rate. It explains about half of the observed increase in the private savings rate but, unlike in the data, the increase is temporary. The model results also explain 80 percent of the increase in the total savings rate.

Our model describes a situation in which households make long-term savings decisions being fully informed about all aspects of the pension system. To assess whether this description is an accurate representation of reality, microdata on the wealth of Swedish households can be explored. In particular, the model yields sharp predictions for discrete changes in the savings behavior between transitional cohorts which can be tested in the data. If the empirical results differ from the model results, this may suggest changes of the model to better capture household savings responses to the pension reform.

aggregate household income and wealth is zero.

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10.1 Definition of aggregate savings rate

The household savings rate in the national accounts relates savings (income less consumption) to income. Income includes labor income as well as capital income. Only disposable income is considered for calculating the private savings rate. Capital income on mandatory funded savings is not included in disposable income since households cannot freely dispose of this income. The private savings rate is defined as

$$\frac{disposable\ income - consumption}{disposable\ income} \tag{11}$$

and is hence a measure of how much households save out of resources that are disposable to them in a given period. The total savings rate relates total savings to total income. It is defined as

$$\frac{disposable\ income + changes\ in\ pension\ claims - consumption}{disposable\ income + changes\ in\ pension\ claims} \tag{12}$$

where *changes in pension claims* denote net forced savings in funded pension schemes. This term is defined as the sum of contributions into funded pension schemes and capital income on funded pension wealth, less pension benefits paid out to retirees.

10.2 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 her working life. An individual might also receive higher returns to her contributions to a funded system than the implicit return to contributions to a PAYGO system, consisting 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.

10.3 Net labor income during working life

Pension contributions and benefits are based on the pre-tax labor income that is paid out to workers, which is denoted by $Y_t^{\mathcal{T}}$ for a worker of type $\mathcal{T} \in \{\mathcal{B}, \mathcal{W}\}$ at age t. We define the total labor cost per worker as

$$\hat{Y}_t^{\mathcal{T}} \equiv (1+\lambda) Y_t^{\mathcal{T}} \tag{13}$$

where λ denotes the pension contribution. We assume that unless there was a pension system, this total labor cost would be paid directly to workers and corresponds to gross labor income. Moreover, we assume that $\hat{Y}_t^{\mathcal{T}}$ is given by the production technology and is constant over time. This assumption implies that changes in the contribution rates λ are borne by employees and affect disposable income.

The gross labor income cannot be observed in the data. In practice, we let $\hat{Y}_t^{\mathcal{T}}$ be determined by the estimated gross labor income in year s_0. We define net labor income (disposable income) per worker as the gross income less pension contributions:

$$Y_t^{\mathcal{T},net} \equiv \hat{Y}_t^{\mathcal{T}} - \lambda Y_t^{\mathcal{T}}. \tag{14}$$

On a balanced growth path, $Y_t^{\mathcal{T}} = Y_t^{\mathcal{T},net}$. During the transition, however, $Y_t^{\mathcal{T}}$ and $Y_t^{\mathcal{T},net}$ can differ. For cohort t and year s, we have that

$$Y_{t,s}^{\mathcal{T},net} = \hat{Y}_{t,0}^{\mathcal{T}} - \lambda_s Y_{t,s}^{\mathcal{T}} \quad \forall s = \{0,1,2,3,...\} \tag{15}$$

Below are the specific definitions of net labor income, as pertaining to the old and new pension systems. Net labor income $Y_t^{\mathcal{T},net}$ in the old pension system is given by

$$Y_t^{\mathcal{T},net} = \begin{cases} \hat{Y}_t^{\mathcal{W}} - (\lambda_t^{pub} + \lambda_t^{\mathcal{W},occ} + \lambda^{itpk}) Y_t^{\mathcal{W}} & \text{if } t < T_{ret} \text{ and } \mathcal{T} = \mathcal{W} \\ \hat{Y}_t^{\mathcal{B}} - (\lambda_t^{pub} + \lambda_t^{\mathcal{B},occ}) Y_t^{\mathcal{B}} & \text{if } t < T_{ret} \text{ and } \mathcal{T} = \mathcal{B} \\ Y^{pub} + Y^{\mathcal{W},occ} + Y^f & \text{if } t \geq T_{ret} \text{ and } \mathcal{T} = \mathcal{W} \\ Y^{pub} + Y^{\mathcal{B},occ} & \text{if } t \geq T_{ret} \text{ and } \mathcal{T} = \mathcal{B} \end{cases} \tag{16}$$

where λ_t^{pub} is the contribution rate to the public pension system, $\lambda_t^{\mathcal{W},occ}$ is the contribution rate to the occupational PAYGO system and λ^{itpk} is the contribution rate to the occupational funded system. Y^{pub} denotes pension received from the public system and $Y^{\mathcal{T},occ}$ denotes pensions received from the occupational PAYGO system. Y^f denotes pensions received from the occupational funded system. Hence, in working life, net labor income equals gross labor income less the total contributions to public and occupational pension schemes. In retirement, gross income and net income coincide since there are no additional taxes.

Net labor income $Y_t^{\mathcal{T},net}$ in the new pension system is given by

$$Y_t^{\mathcal{T},net} = \begin{cases} \hat{Y}_t^{\mathcal{T}} - (\lambda^p + \lambda^f + \tau_t)Y_t^{\mathcal{T}} & \text{if } t < T_{ret} \text{ and } Y_t^{\mathcal{T}} \leq \overline{Y} \\ \\ \hat{Y}_t^{\mathcal{T}} - (\lambda^p + \lambda^f + \tau_t)\overline{Y} & \\ -(\overline{\lambda}^f + \tau_t)(Y_t^{\mathcal{T}} - \overline{Y}) & \text{if } t < T_{ret} \text{ and } Y_t^{\mathcal{T}} > \overline{Y} \\ \\ \max\{\underline{Y}^N, Y^p\} + Y^f & \text{if } t \geq T_{ret} \end{cases} \tag{17}$$

where λ^p is the contribution rate to the public pension system, λ^f is the contribution rate to the PPM and occupational schemes below the income ceiling $\overline{Y}$, τ_t is the pension tax used to fund the minimum guaranteed pension $\underline{Y}^N$, and $\overline{\lambda}^f$ is the contribute rate to the occupational schemes above the income ceiling $\overline{Y}$. Y^p and Y^f are the annuities of the balances at retirement on the notional PAYGO account and the funded pension account, respectively.

10.4 Pension income

Pension income in old system

Pension income from the public scheme is given by

$$Y^{pub} = \underline{Y}^O + \rho \overline{PP}^m_{T_{ret}-1} \tag{18}$$

where $\underline{Y}^O$ is the guaranteed minimum pension income in the old pension system and ρ is the replacement rate in terms of the average of pension points (PP) from the m highest income-years prior to retirement ($\overline{PP}^m$).

Pension income from the blue-collar occupational scheme with PAYGO financing is given by

$$Y^{\mathcal{B},occ} = \rho^{\mathcal{B}} \Big(\max\{0, \min\{Y^{\mathcal{B}}_{T_{ret}-1}, \overline{Y}\} - 1\}\Big) + 1 \tag{19}$$

where $\rho^{\mathcal{B}}$ is the replacement rate for blue-collar workers from the occupational scheme.

Pension income from the white-collar occupational scheme with PAYGO financing is given by

$$Y^{\mathcal{W},occ} = \begin{cases} \rho_1^{\mathcal{W}} \max\{0, \min\{\overline{Y}, Y^{\mathcal{W}}_{T_{ret}-1}\}\} \quad + \\ \rho_2^{\mathcal{W}} \Big(\max\{0, Y^{\mathcal{W}}_{T_{ret}-1} - \overline{Y}\} - \max\{0, Y^{\mathcal{W}}_{T_{ret}-1} - \overline{Y}_2^{\mathcal{W}}\}\Big) \quad + \\ \rho_3^{\mathcal{W}} \Big(\max\{0, Y^{\mathcal{W}}_{T_{ret}-1} - \overline{Y}_2^{\mathcal{W}}\} - \max\{0, Y^{\mathcal{W}}_{T_{ret}-1} - \overline{Y}_3^{\mathcal{W}}\}\Big) \end{cases} \tag{20}$$

where $\rho_1^{\mathcal{W}}$, $\rho_2^{\mathcal{W}}$ and $\rho_3^{\mathcal{W}}$ 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 $\overline{Y} < \overline{Y}_2 < \overline{Y}_3$). As for the public scheme above, replacement rates are expressed in terms of labor income in the period prior to retirement.

The law of motion for funded pension wealth is given by

$$W_{t+1}^f = (1+r)W_t^f + \lambda^{itpk} Y_{t+1} \tag{21}$$

and this pins down income Y^f from the funded white-collar occupational pension system ($ITPK$). Specifically, Y^f equals the annuity of funded pension wealth prior to retirement ($W_{T_{ret}-1}^f$), given the time in retirement ($T - T_{ret} + 1$) and the rate of return (r):

$$Y^f = \frac{(1+r)^{T-T_{ret}+1}}{\sum_{k=0}^{T-T_{ret}} (1+r)^k} W_{T_{ret}-1}^f \tag{22}$$

where funded pension wealth prior to retirement is given by

$$W_{T_{ret}-1}^f = (1+r)^{T_{ret}-1} W_0^f + \sum_{t=1}^{T_{ret}-1} (1+r)^{(T_{ret}-1)-t} \lambda^{itpk} Y_t. \tag{23}$$

We assume that individuals start with no funded pension wealth: $W_0^f = 0$.

Pension income in new system

Pension income from funded wealth Y^f is given by Equation 22. Pension income from notional public pension wealth is given by

$$Y^p = \frac{(1+g)^{T-T_{ret}+1}}{\sum_{k=0}^{T-T_{ret}} (1+g)^k} W_{T_{ret}-1}^p. \tag{24}$$

The law of motions for funded and notional public pension wealth are

$$W_{t+1}^p = (1+g)W_t^p + \lambda^p \min\{\overline{Y}, Y_{t+1}^{\mathcal{T}}\} \tag{25}$$

$$W_{t+1}^f = \begin{cases} (1+r)W_t^f + \lambda^f Y_{t+1}^{\mathcal{T}} & \text{if } Y_{t+1}^{\mathcal{T}} \leq \overline{Y} \\ \\ (1+r)W_t^f + \lambda^f \overline{Y} & \\ +\overline{\lambda}^f (Y_{t+1}^{\mathcal{T}} - \overline{Y}) & \text{otherwise} \end{cases} \tag{26}$$

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

$$W^p_{T_{ret}-1} = (1+g)^{T_{ret}-1} W^p_0 + \sum_{t=1}^{T_{ret}-1} (1+g)^{(T_{ret}-1)-t} \lambda^p \min\{\overline{Y}, Y^{\mathcal{T}}_{t+1}\} \tag{27}$$

$$W^f_{T_{ret}-1} = (1+r)^{T_{ret}-1} W^f_0 + \sum_{t=1}^{T_{ret}-1} (1+r)^{(T_{ret}-1)-t} \left(\lambda^f \min\{\overline{Y}, Y^{\mathcal{T}}_{t+1}\} \overline{\lambda}^f \max\{0, Y^{\mathcal{T}}_{t+1} - \overline{Y}\}\right) \tag{28}$$

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

10.5 Pension provider

Pension provider in old system

The pension provider balances its budget for the public pension scheme. In each year, the pension provider solves for the contribution rate λ^{pub} to ensure that payments into the system equal payments out of the system. We assume that the rate at which young individuals of age T_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 θ. The balanced budget condition is then

$$\sum_{t=1}^{T_{ret}-1} \Phi_t (1+n)^{T-t} \left(\theta CO^{\mathcal{B}} + (1-\theta) CO^{\mathcal{W}}\right) \tag{29}$$

$$= \sum_{t=T_{ret}}^{T} \Phi_t (1+n)^{T-t} \left(\theta PI^{\mathcal{B}} + (1-\theta) PI^{\mathcal{W}}\right) \tag{30}$$

where $CO^{\mathcal{T}}$ denotes the contributions paid in by workers and $PI^{\mathcal{T}}$ denotes the pension income of retirees of type $\mathcal{T} \in \{\mathcal{B}, \mathcal{W}\}$. Similar to above, Φ_t is the conditional survival probability at age t.

Contributions paid in by workers are given by

$$CO^{\mathcal{T}} = \int \lambda^{pub} Y_t \, d\Omega(Z, t, \mathcal{T}) \tag{31}$$

where $\Omega(Z, t, \mathcal{T})$ is the distribution of individuals of type $\mathcal{T}$ and age t with state space Z (see Appendix **??**).

Contributions paid in by workers are given by

$$PI^{\mathcal{T}} = \int \underline{Y}^O + \rho \overline{PP}^m_{T_{ret}-1} \, d\Omega(Z, t, \mathcal{T}). \tag{32}$$

The PAYGO occupational schemes are financed within occupational groups, so that blue-collar (white-collar) workers fund occupational pensions for blue-collar (white-collar) retirees. The balanced budget conditions for the occupational PAYGO schemes are thus similar to Equation 30, with contributions and pension incomes defined as in Section 10.4. The balanced budget condition for each worker type is then

$$\sum_{t=1}^{T_{ret}-1} \Phi_t (1+n)^{T-t} \int \lambda^{\mathcal{T},occ} Y_t \, d\Omega(Z,t,\mathcal{T}) = \sum_{t=T_{ret}}^{T} \Phi_t (1+n)^{T-t} Y^{\mathcal{T},occ}. \tag{33}$$

On a balanced growth path, λ^{pub} will be constant. During the demographic transition, we solve for year-specific λ^{pub} by solving the balanced budget condition above for each year.

10.5.1 Pension provider in new system

The tax τ that is used to fund the minimum guaranteed pension income $\underline{Y}^N$ is set by solving a similar balanced budget condition as in Equation (30), where the contributions paid in, $CO^{\mathcal{T}}$, and the pension income of retirees, $PI^{\mathcal{T}}$, are set to

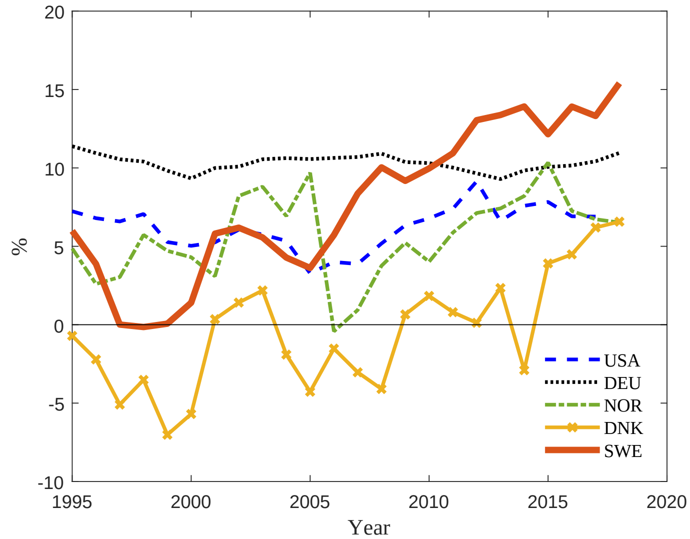
$$CO^{\mathcal{T}} = \int \tau Y_t \, d\Omega(Z,t,\mathcal{T}) \tag{34}$$

$$PI^{\mathcal{T}} = \int \underline{Y}^N - Y^p \, d\Omega(\tilde{Z},t,\mathcal{T}) \tag{35}$$

where $\tilde{Z}$ is the distribution of individuals with public pension incomes Y^p lower than the minimum guaranteed pension income $\underline{Y}^N$. Thus, the revenues from the pension tax are 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 income during retirement. On a balanced growth path after the pension reform, we find that the tax rate τ levied on all income to finance this basic pension amounts to 2.5 percent.

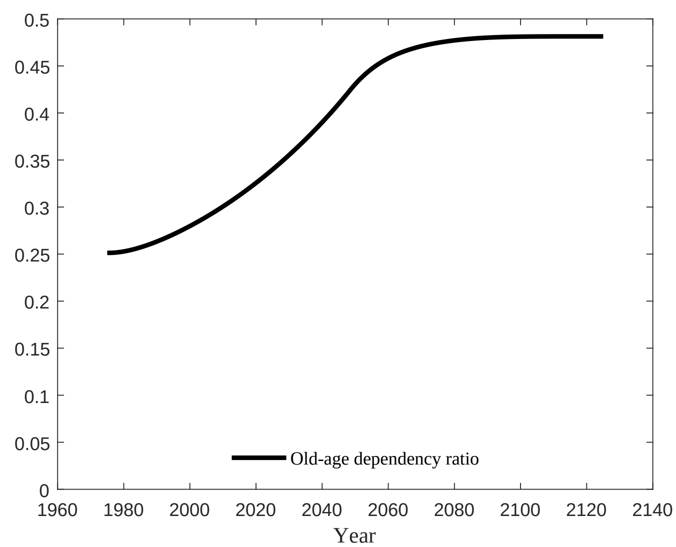
10.6 Figures

Figure 11: Household savings rate in selected OECD countries (percent)



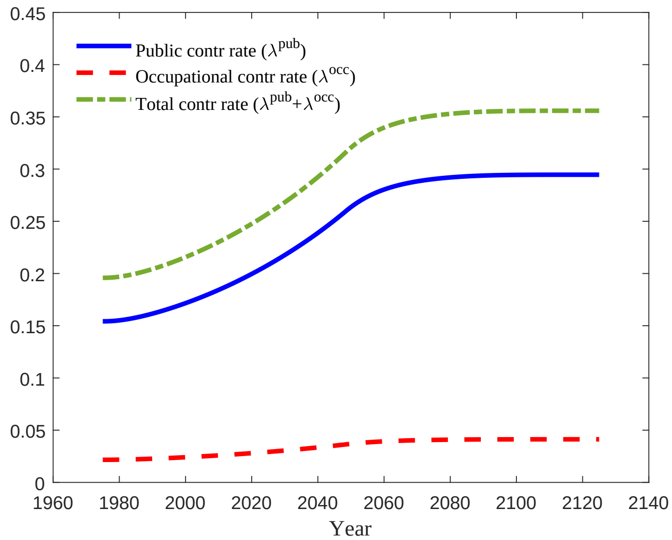
Notes: Total savings rate according to the definition in Appendix 10.1. Source: OECD.

Figure 12: Old-age dependency ratio (ODR).

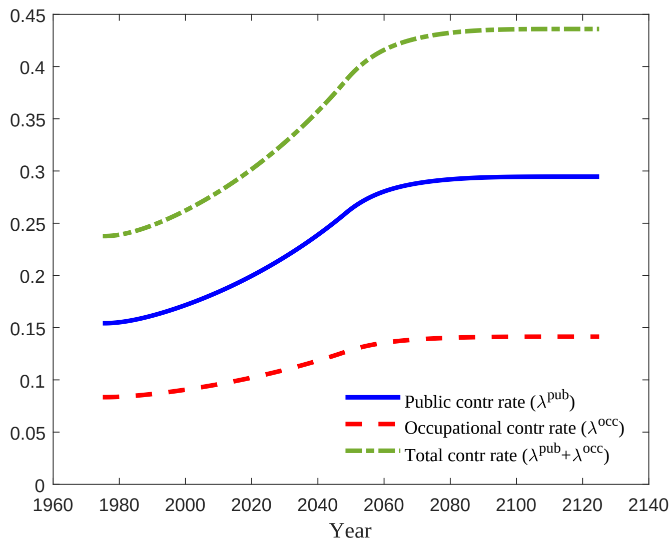


Notes: Calibrated ODR path used for demographic transition.

Figure 13: Contribution rates without the pension reform



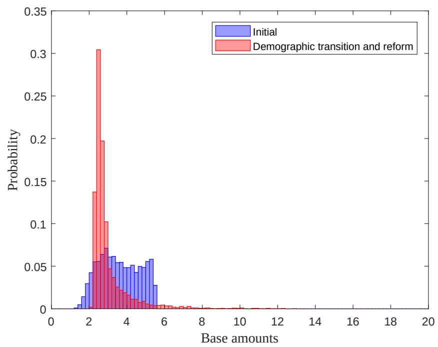
(a) blue-collar workers



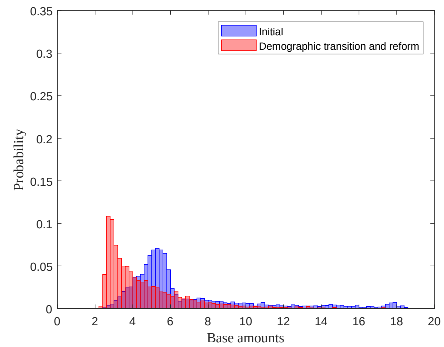
(b) white-collar workers

Notes: Contribution rates without the pension reform. The white-collar occupational contribution rate includes an endogenous component that changes with demographics, and an exogenous constant contribution rate to a funded scheme (ITPK). The blue-collar occupational contribution rate and the public contribution rate are determined by an endogenous component only.

Figure 14: Distribution of pension income



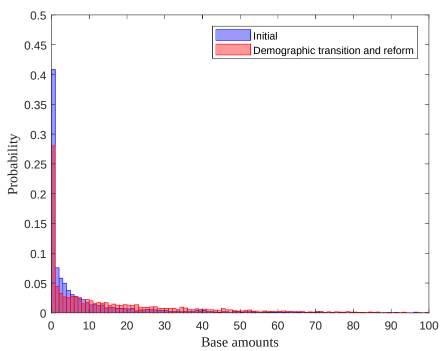
(a) blue-collar workers



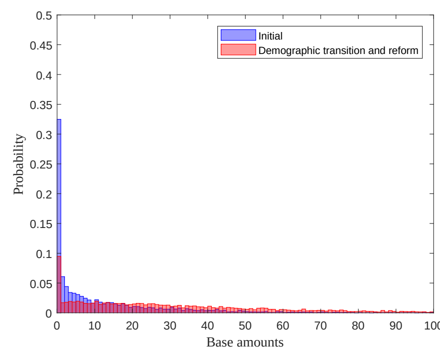
(b) white-collar workers

Notes: Distribution of pension income on a balanced growth path in the initial scenario and the scenario with demographic transition and pension reform. The pension income is constant throughout retirement.

Figure 15: Distribution of private wealth



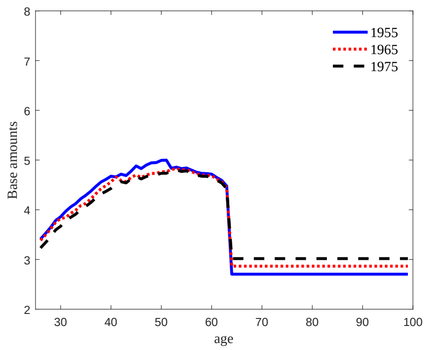
(a) blue-collar workers



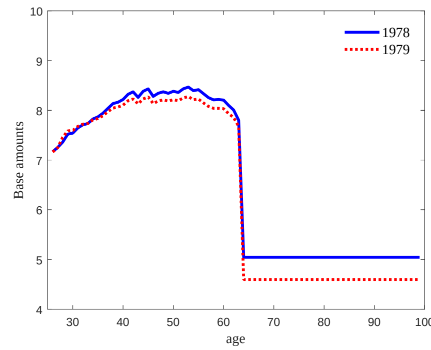
(b) white-collar workers

Notes: Distribution of private wealth on a balanced growth path in the initial scenario and the scenario with demographic transition and pension reform. Individuals aged 65 years.

Figure 16: Average net labor income - transitional cohorts



(a) blue-collar workers



(b) white-collar workers

Notes: Average net labor income for cohorts with full exposure to the new public pension system but different exposure to the new occupational pension system. Among blue-collar workers, exposure is increasing with age. Among white-collar workers, the cohort born in 1978 is entirely in the old occupational pension system whereas the cohort born in 1979 is entirely in the new occupational pension system.

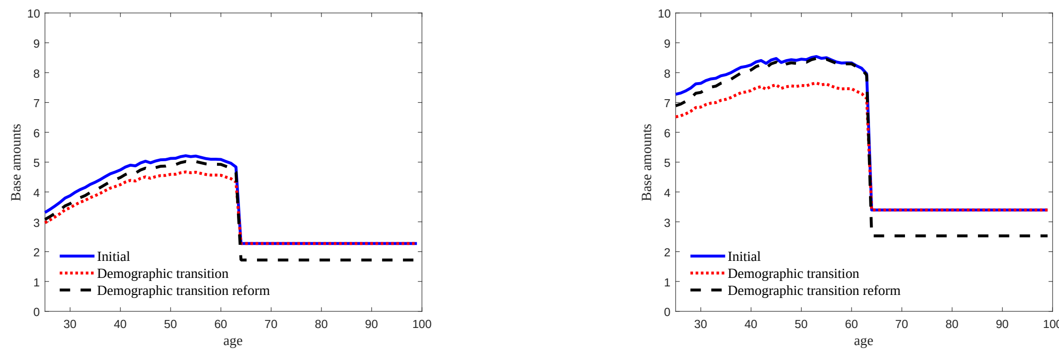
10.7 Effects on income of different parts of the pension reform

What is the role played by the public pension system, the occupational system and the minimum guaranteed pension for household income? Figure 17 compares average life-cycle net labor income considering only contributions paid to and benefits received from the public pension system. The replacement rate does, on average, drop from 47 to 35 percent for blue-collar workers and from 42 percent to 30 percent for white-collar workers. Hence, if it were only for the public system, blue-collar workers and white-collar workers would experience equally large drops in the replacement rate. Figure 17 also shows that public pensions for blue-collar workers in the new system do, on average, fall below 2 base amounts. This means that minimum guaranteed pensions that raise public pensions up to 2 base amounts are an important feature of the new pension system.

Comparing Figure 17 and Figure 18 shows the role of the minimum guaranteed pension in raising pension income, in particular for blue-collar workers. Under the old system, a minimum guaranteed pension was given to everyone in addition to the earned pension income. Hence, the minimum guaranteed pensions did, on average, increase the replacement rate by 19 percentage points for blue-collar workers and by 12 percentage points for white-collar workers. In the new system, two thirds of blue-collar workers but very few white-collar workers receive some minimum guaranteed pension. The effect on the average replacement rate is 13 percentage points and 2 percentage points, respectively.

Comparing Figure 18 and Figure 4 illustrates the important role of the occupational pension system in countering the drop in the average replacement rates when transitioning from the old to the new system. In the old system, occupational pensions did, on average, account for 11 percent of pension income for blue-collar workers and 35 percent for white-collar workers. In the new system, it does, on average, account for 25 percent and 44 percent, respectively.

Figure 17: Average net labor income - public system only

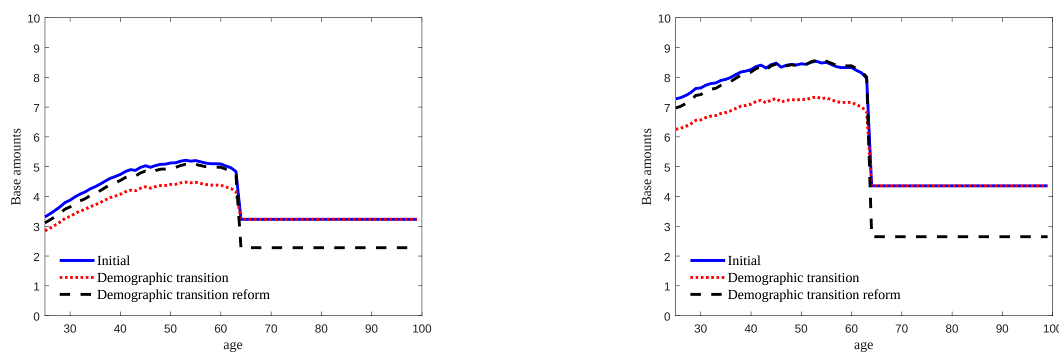


(a) blue-collar workers

(b) white-collar workers

Notes: Average net labor income on a balanced growth path under three scenarios. Income only considering contributions paid to and benefits received from the public pension system.

Figure 18: Average net labor income - public system and minimum guaranteed pension



(a) blue-collar workers

(b) white-collar workers

Notes: Average net labor income on a balanced growth path in three scenarios. Income only considering contributions paid to and benefits received from the public pension system and the minimum guaranteed pension.

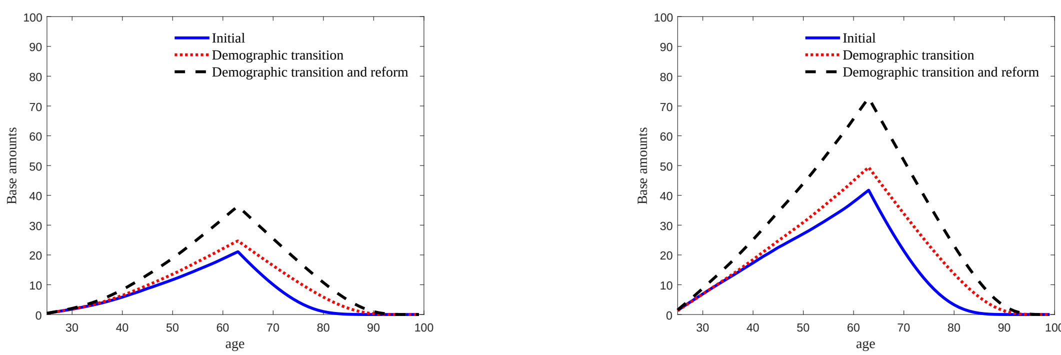
10.8 Effects on savings of different parts of the pension reform

What is the role played by the public pension system, the occupational system and the minimum guaranteed pension for household income? Figure 19 shows average accumulated private savings considering the public pension system only. We see that private wealth is almost twice as high compared to when all pillars of the pension system are in place, see Figure 5. After the pension reform, the average 60-year old blue-collar worker has now saved 32 base amounts and the average white-collar worker of the same age has saved 66 base amounts. This illustrates the importance of considering the entire pension system when making predictions for household private savings.

Figure 20 shows average accumulated private savings considering the public pension system and the minimum guaranteed pension system but not the occupational pension system. The old minimum guaranteed pension contributes to significantly lower savings in the initial scenario and the future counterfactual scenario without the pension reform. Here, the minimum guaranteed pension does, on average, explain about half of the difference between the savings that would have prevailed when considering the public system only and the savings when considering the entire pension system. The remaining half is explained by the occupational pension system.

In the scenario with the pension reform, the minimum guaranteed pension continues to play an important role for blue-collar workers. Similar to under the old system, the average minimum guaranteed pension explains about half of the difference between savings considering the public system only and considering all pillars of the pension system. In contrast, the minimum guaranteed pension plays only a marginal role for the savings decision of white-collar workers in the new pension system. The average 60-year old white-collar worker still saves 65 base amounts, marginally less than considering the public system only. This clearly illustrates the importance of the occupational pension system, especially for white-collar workers, in the new pension system.

Figure 19: Average wealth - public system only

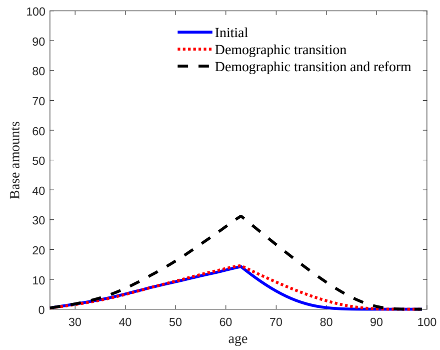


(a) blue-collar workers

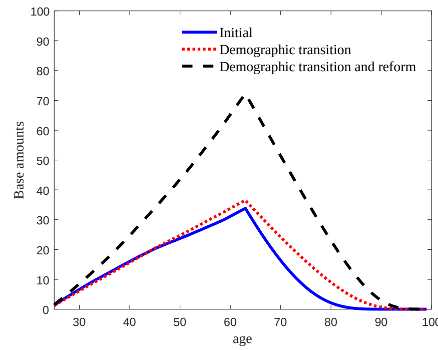
(b) white-collar workers

Notes: Average private liquid wealth on a balanced growth path in three scenarios. Wealth only considering contributions paid to and benefits received from the public pension system.

Figure 20: Average wealth - public system and minimum guaranteed pension



(a) blue-collar workers



(b) white-collar workers

Notes: Average private liquid wealth on a balanced growth path in three scenarios. Wealth only considering contributions paid to and benefits received from the public pension system and the minimum guaranteed pension.

10.9 Equilibrium definitions

In any pension system, individuals are heterogeneous with respect to type $\mathcal{T} \in \{\mathcal{W}, \mathcal{B}\}$, age $t \in \mathcal{H} = \{1, 2, ..., T\}$, the 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 $\mathcal{T}$ of age t is defined as the sum of liquid financial wealth and net labor income: $X_t = (1+r)A_{t-1} + Y_t^{\mathcal{T},net}$. In the old pension system, blue-collar workers ($\mathcal{T} = \mathcal{B}$) are also heterogeneous with respect to pension points from the m best income years $\overline{PP}^m \in \mathcal{PP} = \mathbb{R}_+$, and white-collar workers ($\mathcal{T} = \mathcal{W}$) are also heterogeneous with respect to funded pension wealth $W^f \in \mathcal{A}^{\mathcal{F}} = \mathbb{R}_+$. In contrast to the old pension system, individuals in the new pension system are also heterogeneous with respect to notional defined-contribution PAYGO wealth $W^p \in \mathcal{A}^{\mathcal{P}} = \mathbb{R}_+$. Let $\mathcal{Z} = \{\mathcal{P} \times \mathcal{X} \times \mathcal{PP} \times \mathcal{A}^{\mathcal{F}} \times \mathcal{A}^{\mathcal{P}}\}$ be the non-deterministic state space with $\mathbf{z} = (P, X, \overline{PP}^m, W^f, W^p)$ 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 $B(\mathcal{Z}) = \{\mathbf{B}(\mathbb{R}_{++}) \times \mathbf{B}(\mathbb{R}_{++}) \times \mathbf{B}(\mathbb{R}_+) \times \mathbf{B}(\mathbb{R}_+) \times \mathbf{B}(\mathbb{R}_+)\}$. If $\mathbb{M}$ is the set of all finite measures over the measurable space $(\mathcal{Z}, B(\mathcal{Z}))$, then $\Omega(Z, t, \mathcal{T}) \in \mathbb{M}$ is a probability measure defined on subsets $Z \in B(\mathcal{Z})$ that describes the distribution of individual states across agents with age $t \in \mathcal{H}$ and of type $\mathcal{T} \in \{\mathcal{B}, \mathcal{W}\}$.

Since states W^f and W^p are redundant in the old pension system, the sparse state space can be expressed as $\mathcal{Z}^O = \{\mathcal{P} \times \mathcal{X} \times \mathcal{PP}\}$ with $\mathbf{z^O} = (P, X, \overline{PP}^m)$ 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 $\mathbf{z^N} = (P, X, W^f, W^p)$.

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 still 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 $V_t^{\mathcal{T}}(\mathbf{z^O})$ with associated policy functions $C_t^{\mathcal{T}}(\mathbf{z^O})$ and $A_t^{\mathcal{T}}(\mathbf{z^O})$ for all t and $\mathcal{T}$, contribution rates to the public and occupational schemes λ^{pub} and $\lambda^{\mathcal{T},occ}$, and a distribution of states $\Omega(Z^O, t, \mathcal{T})$ for all t and $\mathcal{T}$ such that

- $V_t^{\mathcal{B}}(\mathbf{z^O})$ solves (7) and $V_t^{\mathcal{W}}(\mathbf{z^O})$ solves (7) with the additional constraint (8), for all t.
- λ^{pub} solves the balanced budget condition (30), satisfying (31) and (32), and $\lambda^{\mathcal{T},occ}$ solves (33) for all $\mathcal{T}$.
- The distribution of states $\Omega(Z^O, t, \mathcal{T})$ is given by the following law of motion for all t and $\mathcal{T}$

$$\Omega(\mathcal{Z}^O, t+1, \mathcal{T}) = \int_{Z^O} Q_t(\mathbf{z^O}, \mathcal{Z}^O) d\Omega(Z^O, t, \mathcal{T})$$

  where $Q_t \ : \ \mathcal{Z}^O \times \mathcal{B}(\mathcal{Z}^O) \to [0,1]$ 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 $V_t^{\mathcal{T}}(\mathbf{z^N})$ with associated policy functions $C_t^{\mathcal{T}}(\mathbf{z^N})$ and $A_t^{\mathcal{T}}(\mathbf{z^N})$ for all t and $\mathcal{T}$, a pension tax τ that finances minimum guaranteed pension payments, and a distribution of states $\Omega(Z^N, t, \mathcal{T})$ for all t and $\mathcal{T}$ such that

- $V_t^{\mathcal{T}}(\mathbf{z^N})$ solves (9) for all t and $\mathcal{T}$.
- τ solves the balanced budget condition (30), satisfying (34) and (35).
- The distribution of states $\Omega(Z^N, t, \mathcal{T})$ is given by the following law of motion for all t and $\mathcal{T}$

$$\Omega(\mathcal{Z}^N, t+1, \mathcal{T}) = \int_{Z^N} Q_t(\mathbf{z^N}, \mathcal{Z}^N) d\Omega(Z^N, t, \mathcal{T})$$

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 $s \in [s_{initial}, s_{final}]$, and time-varying vectors for birth rates $\{n_s\}_{s \in [s_{initial}, s_{final}]}$ and survival rates $\{\phi_{t,s}\}_{s \in [s_{initial}, s_{final}]}$, for all t, which determine the demographic transition between $[s_{initial}, s_{final}]$. The economy permits a balanced growth equilibrium with the old pension system for the years before $s_{initial}$ and after s_{final}.

Transitional equilibrium with the pension reform

A *partial transitional recursive equilibrium with the pension reform* is a collection of (1) the same birth and survival rates as in the partial transitional recursive equilibrium with the old system;

(2) implementation rules $\{s_{announcement}, I^{\mathcal{T}}\}$, where $s_{announcement} \in (s_{initial}, s_{final})$ is the year at which agents are informed about the reform and $I^{\mathcal{T}}$ is an implementation rule specifying the years in which the old pension systems are replaced by the new pension systems for each $\mathcal{T}$.

10.10 Numerical solution

The individual problem cannot be solved analytically. As there are up to six exogenous state variables (worker type, age, persistent income, pension points, NDC PAYGO wealth and funded pension wealth) and only one endogenous state variable (cash-in-hand), 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).