Life-Cycle Responses to Pension Reform: The Role of Subjective Policy Beliefs

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This study quantifies the impact of *Statutory Retirement Age* (SRA) reforms on individual behavior and welfare in the presence of subjective beliefs about the policy environment. We elicit policy beliefs from novel survey data and estimate a rich structural life-cycle model of labor supply, retirement, and savings decisions. In the model, agents have probabilistic expectations about the future evolution of the SRA (*policy uncertainty*) and strongly overestimate the penalty for early retirement (*misinformation*). Our results show that while these beliefs distort behavior and reduce individual welfare, they can support policy objectives. While increases in the SRA delay retirement and boost old-age labor supply, we estimate negative reform effects on labor supply and savings of younger agents. Policy uncertainty attenuates these negative effects by 20-50 percent while maintaining effectiveness at the retirement margin. Eliminating misinformation would cause individuals to retire around 1.1 years earlier and reduce lifetime labor supply by 3.2 percent.

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1. Introduction

Ageing populations are straining social security systems across the world, prompting governments to continuously discuss reforms of the pension systems. Since the immediate effects of such reforms only emerge at the end of one's working life, behavioral responses critically depend on the beliefs about future policy. We study how subjective pension policy beliefs affect behavior over the life-cycle and how they moderate the effects of policy reform. We distinguish between *policy misinformation* - systematic misperception about existing policy features - and *policy uncertainty* - individuals' probabilistic expectations about how policy parameters will evolve. While misinformation could be the result of either a lack of salience or of (potentially rational) inattention (Bordalo et al., 2022; Gabaix, 2019), uncertainty is the fundamental unpredictability of the future policy environment (Caplin et al., 2022; Ciani et al., 2023). To quantify subjective policy belief dynamics, we collect survey evidence and analyze how beliefs evolve over the life-cycle. We study the interaction of these beliefs with policy reforms in a comprehensive life-cycle framework. In the model, agents make annual savings and labor supply decisions during their working lives and choose when to retire and claim their pensions.

The key mechanism through which policy beliefs affect behavior in our model is the expected timing of retirement. The *direct* effect of reforms that reduce the generosity of the pension system is an increase in savings[1] as well as labor supply, at least for workers who are close to retirement.[2] Since Feldstein (1974), it has been recognized that when pension reforms affect retirement timing, *indirect* effects can be large and typically counteract these direct reform effects. The main reason for indirect effects is that reforms delaying retirement reduce the need to generate resources to finance old-age consumption. As a result, a conflict of policy goals arises, in which reforms aimed at boosting old-age labor supply may have adverse effects on the behavior of people far from retirement. Thus, a key challenge in predicting responses to policy reform is understanding how subjective beliefs about the future policy environment shape retirement timing expectations.

The policy reforms we study are increases of the *Statutory Retirement Ages* (SRA), which have the express objective of delaying retirement timing and to boost old-age labor supply.[3] The SRA in Germany is the reference age after which a full pension can first be claimed under the standard old-age pension scheme. It is not a strict constraint for the majority of people. Under relatively mild conditions, early retirement is possible at a cost of 3.6 percent of the pension per year of early retirement, the *Early Retirement Penalty* (ERP). In other words, for someone wishing to retire before the SRA, the SRA determines how many years of early retirement they must "purchase," while the ERP sets the price. Together, beliefs about these policies govern the time and conditions under which people can expect to retire and claim their pensions.

We model the perception of the ERP as being subject to *misinformation*, and the perception

[1] See, for example, Attanasio and Rohwedder (2003); Attanasio and Brugiavini (2003); Alessie et al. (2013); Lachowska and Myck (2018).

[2] See, for example, Manoli and Weber (2016a); Fetter and Lockwood (2018); Gelber et al. (2022). For workers who are further from retirement, quasi-experimental evidence is scarcer, with some recent exceptions (Artmann et al., 2023). This is in part because many reforms that also affect younger workers do not only have income effects but also change work incentives, such as the pension-contribution link (cf. French et al., 2022).

[3] Modifications of pension eligibility ages are among the most common types of public pension reforms. For example, in the 2023 version of the biennial OECD pension report, 9 out of 21 recent pension reforms in OECD countries were changes of the SRA (Scarpetta and di Noia, 2023). See also Börsch-Supan and Coile (2021) for a systematic overview of four decades of pension reforms in selected countries.

of the SRA as being subject to *policy uncertainty*. Frequent reforms and ongoing public debate make the SRA a salient feature of the pension system, but this same dynamic creates uncertainty about what the future SRA will be. Accordingly, subjective probabilistic expectations of the *future* SRA are our measure of policy uncertainty. In contrast to the SRA, the ERP, which has never been changed since its introduction in 1992, is much less salient and largely absent from public discourse, making knowledge of this parameter key to its effect on behavior.[4] We elicit probabilistic beliefs about SRA and ERP in a questionnaire, which we included in the *Socio-Economic Panel Innovation Sample* (SOEP-IS) (cf. Manski, 2004).[5]

Survey respondents in our SOEP-IS questionnaire on average expect further SRA increases and are uncertain about its future development, which is in line with existing research on pension policy uncertainty (Caplin et al., 2022; Luttmer and Samwick, 2018). Respondents closer to retirement expect smaller increases and report lower forecast uncertainty. This finding is consistent with a model in which, over time, expectations and policy converge, while policy uncertainty gradually resolves. We formalize expectation formation using a nonstationary, autoregressive process, similar to Hentall-MacCuish (2025). This allows us to estimate the long-term effects of expected reforms in a realistic framework, and contrast them with that of unexpected reforms, which the literature typically focuses on. As an example, the estimated process-implied expectation of a 30-year old with a current SRA of 67 is that by the time she retires, the SRA will have risen to around 68.5 years, with a standard deviation of around one year.

Our survey evidence further reveals that respondents, on average, strongly overestimate the ERP. The average respondent overestimates the ERP by a factor of more than 3, suggesting that many respondents hold early retirement to be almost prohibitively expensive. Based on this finding, we classify respondents into "informed" and "misinformed".[6] In line with previous research, our survey evidence also shows that while people on average are misinformed about current pension policy rules (e.g., Bottazzi et al., 2006; Delavande and Rohwedder, 2011), beliefs become more accurate at higher ages (Manski, 2004; Rohwedder and Kleinjans, 2006). We formalize belief updating with a simple exogenous updating process, with education-specific information hazard rates. The process predicts that she share of correctly informed people increases from 18-27 percent at age 25 to 38-55 percent at age 65. The main consequence of misinformation in our life-cycle model is that agents expect to delay retirement much more as a response to policy reform than would be consistent with a classical model, in which people expect to respond only to financial incentives.

We incorporate misinformation and policy uncertainty in a life-cycle model of savings, labor supply, and endogenous retirement in the tradition of French (2005). In the model, men and women make labor supply and savings decisions while forming expectations about their retirement timing. The model includes key retirement timing incentives studied in the literature

[4]While researchers do not all agree if the ERP is actuarially fair (cf. Börsch-Supan et al., 2016), there is no *public* debate about changing it, which previous research has shown to be critical for the formation of policy reform expectations (Ciani et al., 2023). In Appendix A.1, we illustrate this with a frequency analysis of the appearance of the terms "Retirement Age" and "Pension Deduction" (as well as related terms) in major German news outlets.

[5]The SOEP-IS is a rich and representative panel survey of the German population (Richter and Schupp, 2015).

[6]In the life-cycle model, informed agents know the true ERP and misinformed agents hold the median belief of a respondent classified as misinformed in the data. This is similar to the approach of Bairoliya and McKiernan (2025). However, in contrast to their data, misinformation rates in survey responses decline as people approach retirement, suggesting that people learn about the retirement system as they age.

(Blundell et al., 2016b; Fisher et al., 2016), including declining health (Blundell et al., 2023), falling wages Fan et al. (2024), joint leisure with retired partners (Carta and De Philippis, 2024), and age-dependent probabilities of losing or finding a job (Rabaté, 2019; Rabaté et al., 2024). We account for relevant institutional features, such as taxes, transfers, as well as the most important alternative paths to retirement based on disability and long working lives. This allows for program substitution effects, which have been shown to be a common consequences of pension eligibility age reform.(Atalay and Barrett, 2015; Duggan et al., 2007; Staubli and Zweimüller, 2013).

We estimate the model using the core sample of the SOEP, linked with admin data from the German pension insurance (Goebel et al., 2019; Lüthen et al., 2022). Policy belief data are imputed via matching covariates from the SOEP-IS survey data. We estimate the parameters of the model with maximum likelihood (Rust, 1994), explaining the labor supply choices of the respondents in the SOEP-Core, and using the available admin data to refine the observed retirement timing of individuals. The model replicates both the targeted age profiles of labor supply choices and the untargeted wealth distribution over the life-cycle. The estimated model allows us to simulate counterfactual scenarios with varying assumptions about the realized policies and the agents' policy beliefs, and to investigate the interplay of policy beliefs and reforms.

We use the estimated life-cycle model to simulate the effects of SRA reform. In our benchmark estimation, a one-year increase in the SRA leads to a delay in retirement timing by around 0.4 years. This result is consistent with the empirical literature on actual retirement timing responses to SRA increases across countries, which typically finds effect sizes of a similar order of magnitude (Dolls and Krolage, 2023; Manoli and Weber, 2016b; Mastrobuoni, 2009; Lalive et al., 2023). We find relatively small but *negative* forward-looking effects of SRA reforms on saving and labor supply during working life. This is consistent with strong indirect reform effects stemming from the reduction in expected time spent in retirement. While reforms curtail pension wealth, younger agents, who after a reform expect to work longer at higher ages, face a reduced need to generate additional assets for retirement.

Simulations show that without policy uncertainty, reforms would have significantly stronger forward-looking effects on younger agents. Under perfect foresight, which means that agents know the SRA from the beginning of their working lives, SRA increases result in more pronounced reductions in saving and labor supply before age 63. On the margin of actual retirement timing, however, response sizes are not distinguishable between agents with policy uncertainty and those with perfect foresight. This positive reform effect on old-age labor supply is much stronger than the negative effect for younger agents. As a result, the net effect on lifetime labor supply is around 10 percent higher due to policy uncertainty.

Welfare effects of policy reforms are significant and driven by misinformation about the ERP. In the benchmark model, average individual welfare costs amount to 0.23 percent of lifetime consumption per year of SRA increase. For the (initially) misinformed, behavior is distorted more strongly, so welfare effects of the reform are larger than for the informed (-0.25 percent vs. -0.16 percent). We also find larger welfare effects of SRA reforms for low educated people, for whom pension wealth is more important compared to financial wealth, and for for men, who have higher pensions and whose pension therefore typically is a larger component of old-age household income than for women.

Our welfare analysis further reveals that misinformation about the ERP leads young agents to overestimate the welfare cost of policy reform by around 50 percent. Ex ante, misinformed agents do not expect that they can be updated. If they become informed at some point in their lives, they may re-optimize and adapt their behavior, reducing the welfare loss of the reform. The other reason is mechanical: if a misinformed agent retires before the SRA, they pay a lower penalty for it than they anticipated. This finding has implications both for the political economy of policy reform and for its normative evaluation from a social planner perspective.[7]

Eliminating misinformation would improve individual welfare but have strong adverse effects on policy reform goals. For this exercise, we compare the baseline with misinformation and random updating to a counterfactual scenario in which everyone is informed about the ERP from the start. Agents in the counterfactual retire around 1.1 years earlier on average with the same incentives, reducing lifetime labor supply by over 3.1 percent. The effect is driven by men, particularly low-educated men, who when misinformed would not consider early retirement due to the relative importance of their pensions for household income. The individual welfare effect of debiasing is positive albeit moderate, at 0.16 percent of lifetime consumption.

Misinformation about the ERP can produce the well-known spike of retirement decisions at the SRA, which empirical literature across different countries has documented extensively and which cannot be explained by pure financial incentives.[8] In the baseline with misinformation, we show that retirement behavior bunches around the SRA.[9] This is because even close to retirement, around half of the agents are still misinformed, implying they hold early retirement to be very expensive. This incentivizes them to wait until they reach the SRA to retire. In contrast, in the scenario in which everyone is informed, retirement behavior evolves smoothly around the SRA.

1.1. Related Literature

The literature has recently explained bunching either by interpreting the SRA as a normative signal for the appropriate time to retire (e.g. Cribb et al., 2016; Gruber et al., 2022) or with reference-dependent preferences and loss aversion (Behaghel and Blau, 2012; Lalive et al., 2023; Seibold, 2021). We demonstrate that when early retirement is possible, overestimation of the ERP can also generate this pattern.[10] With this finding, we join Hentall-MacCuish (2025) in offering a biased policy belief-based explanation for the bunching of retirement decisions around the SRA. More generally, all these explanations lead agents to expect stronger reactions to retirement timing from SRA reform than would be predicted by a standard model. As we demonstrate that retirement timing expectations drive indirect reform effects, incorporating a behavioral feature like this into a model of responses to SRA reform has significant implications for forward-looking reform responses.

[7] Which welfare criterion is the appropriate one to evaluate policies which are perceived as risky by agents ex ante is subject to debate, as discussed for example in Fleurbaey (2010).

[8] See Lumsdaine et al. (1996); Rust (1997) for an early discussion of the phenomenon in the US.

[9] More precisely, it bunches around the SRA (69) and age 67, at which agents can retire if the conditions for early pension due to long working life are met.

[10] For instance, Lalive et al. (2023) finds that Swiss women, when asked in surveys to state the reason for the time at which they decide to claim, answer that they view claiming at the SRA as ”normal” and that they wanted to avoid penalties. Since the authors find timing decisions to be financially suboptimal, they view this as support for reference-dependence. Respondents overestimating penalty sizes, however, would be another way to rationalize these findings.

Shedding light on the role of probabilistic reform expectations is another way in which we contribute to the large literature that evaluates responses to pension reform through the lens of forward-looking life-cycle models (e.g., Daminato and Padula, 2024; French, 2005; French and Jones, 2011; Gustman and Steinmeier, 2005; Haan and Prowse, 2014; Iskhakov and Keane, 2021; van der Klaauw and Wolpin, 2008). While the importance of reform expectations in evaluating reform responses has long been recognized (Burtless, 1986; Moffitt, 1987), models typically assume that reforms are unexpected because reform expectations are difficult to quantify. Notable exceptions are van der Klaauw and Wolpin (2008), who identify reform expectations from choice data, and Gustman and Steinmeier (2015), who assumes different sets of potential beliefs for policy evolution. In contrast, by using subjective expectations, we avoid making strong assumptions about how those expectations are formed and recover estimates about the uncertainty surrounding them, which would otherwise be difficult to identify. We show that the lower perceived likelihood and decreasing uncertainty at higher ages imply that probabilistic reform expectations particularly affect responses among younger people, who are still far from retirement.

Our results also help reconcile the typical finding of the quasi-experimental literature, which usually finds no significant forward-looking effects of SRA increases on labor supply for younger people.(Geyer and Welteke, 2021; Mastrobuoni, 2009; Staubli and Zweimüller, 2013)[11], which is discussed in detail by Rabaté et al. (2024). Likewise, there is no strong evidence for a positive impact of SRA reform on savings, while some studies even find negative effects.(cf. Etgeton et al., 2023, and the discussion therein). We offer two explanations for the lack of such responses, which are observed for other types of reforms that reduce pension generosity. One explanation is that people expect to postpone retirement significantly, which could be driven by behavioral factors such as misinformation about penalty sizes. Another possibility is that their pre-reform behavior already reflected the expectation of future SRA increases. This could be true even if the reform under study was not itself expected, as our belief data show, which we elicited at a time when no SRA reform was imminent.

A strain of the macroeconomic literature explores the implications of objective pension policy uncertainty in general equilibrium models. Cottle Hunt (2021); Caliendo et al. (2019); Kitao (2018) assume scenarios with probability distributions over future policy parameters to quantify welfare cost of uncertainty about timing and design of inevitable retirement reform.[12] We contribute by showing that, despite the undoubtedly negative effect on individual welfare, efforts to correct misbeliefs or eliminate policy uncertainty may conflict with potential policy goals of stimulating precautionary behavior. We abstract from fiscal or general equilibrium effects here. Including them could be an interesting extension to qualify welfare effects further.

We also contribute to a broader literature on the effects of policy uncertainty. Modeling subjective beliefs about late-in-life policies in structural models is complicated because of the non-stationarity of the policy environment (Koşar and O'Dea, 2023). In the macroeconomic literature, where policies under scrutiny often have tangible effects in the short term, modeling policy uncertainty is much more common. Examples include fiscal policy (Fernández-Villaverde et al., 2015), monetary policy (Born and Pfeifer, 2014), or trade policy (Caldara et al., 2020).

[11] A notable exception is Carta and De Philippis (2024), who finds significant forward-looking increases in labor supply. Note further that for elderly workers who are close to retirement, however, an increase in employment is the usually observed response (in particular, Engels et al. (2017) in the German context; see also Pilipiec et al. (2021) for a literature review)

[12] Luttmer and Samwick (2018) quantifies the welfare effects of subjective pension policy uncertainty with a survey experiment.

Usually, the welfare effect of policy uncertainty is found to be negative in these analyses. An exception to this is Fried et al. (2022), who show that climate policy risk reduces emissions and thereby supports policy objectives. We show another example, in which the presence of reform anticipation in a nonstationary environment can have favorable consequences for policymakers.

The rest of the paper is structured as follows. In Section 2, we outline the most important features of the German retirement system and describe our data. Section 3 describes the policy beliefs, how they are treated in our model, and how we estimate them. In Section 4, we explain our life-cycle model. In Section 5, we lay down our estimation methods and estimation results. In Section 6, we present our counterfactual policy simulations. Section 7 concludes.

2. Institutional Background and Data

Section 2.1 introduces the key features of the German pension system relevant for our research question and Section 2.2 introduces the data we use to analyze them.

2.1. Public Pension Insurance in Germany

Germany has a pay-as-you-go pension system, which is financed by flat-rate contributions from employees and employers. The pension system is mandatory for nearly all employees and, as of 2023, covers 87 percent of the working population (70 percent of people aged 15-64). The most important exceptions are self-employed or marginally employed workers, civil servants, and military personnel.

Public pensions in 2023 provided a replacement rate of 48 percent according to the definition of the German Public Pension Insurance (around 44 percent according to that of the OECD). Pension size depends on work experience and labor earnings history. The pension formula is not inherently redistributive, so replacement rates are similar across income groups[13]. While replacement rates have fallen in recent years, contribution rates have been stable at around 19 percent (cf. Figure 11). Both are linked to demographic change, so without further reform, replacement rates are expected to fall, while contribution rates are expected to rise.

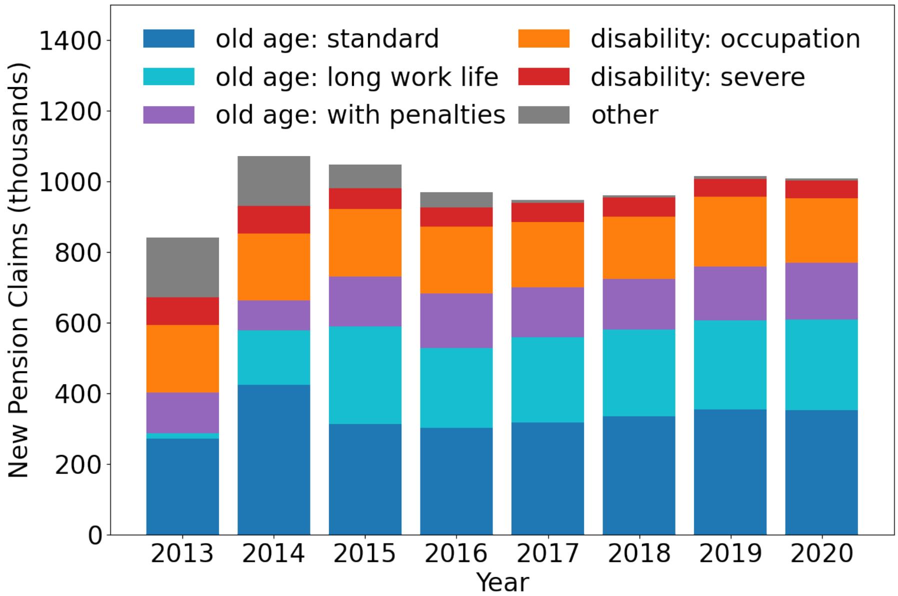
Figure 1 illustrates all paths into retirement. There are two main paths to retirement in Germany: old-age pensions and disability-based pensions. Claiming an old-age pension is possible upon reaching the *Statutory Retirement Age* (SRA). The current SRA is a function of birth year and stands at 67 years for everyone born after 1964. Given certain requirements, claiming a pension is possible up to four years before this age,[14] but no earlier than 63 years. Early retirement generally comes at a penalty (*the Early Retirement Penalty*, ERP) of 3.6 percent of the pension value per year of early retirement, or 0.3 percent per month. [15] However, after a 2013 reform, claiming an old-age pension without penalty is possible up to two years before the applicable SRA for people with very long contribution histories of at least 45 years. The most

[13]This holds until a cap of roughly twice the average wage, beyond which no contributions have to be made and no claims are accumulated

[14]A claimant needs to have 35 years of *credited periods*. In addition to years of work, these include unpaid childcare and elderly care, as well as short-term unemployment and sickness.

[15]In 2023, one in three old-age pensions was claimed before the applicable SRA. On average, pensions that were claimed early were claimed 30 months in advance, implying an average penalty size of 9 percent. In theory, deferring retirement is also possible, which increases the pension size by 6 percent per year of deferral. However, in practice, this option is very rarely used.

Figure 1: New Pension Claims 2013-2020 by Type of Pension



Notes: "Other Pensions" comprise the phased-out pensions for women and for the unemployed. "Occupation-based Disability" and "Severe Disability" Pension ("Erwerbsminderungsrente" and "Rente für Schwerbehinderte" in German) are based on different eligibility criteria and offer earlier retirement or with reduced penalties compared to the ordinary old age pension. Widower pensions are excluded here since they are transfers or existing entitlements rather than new claims.

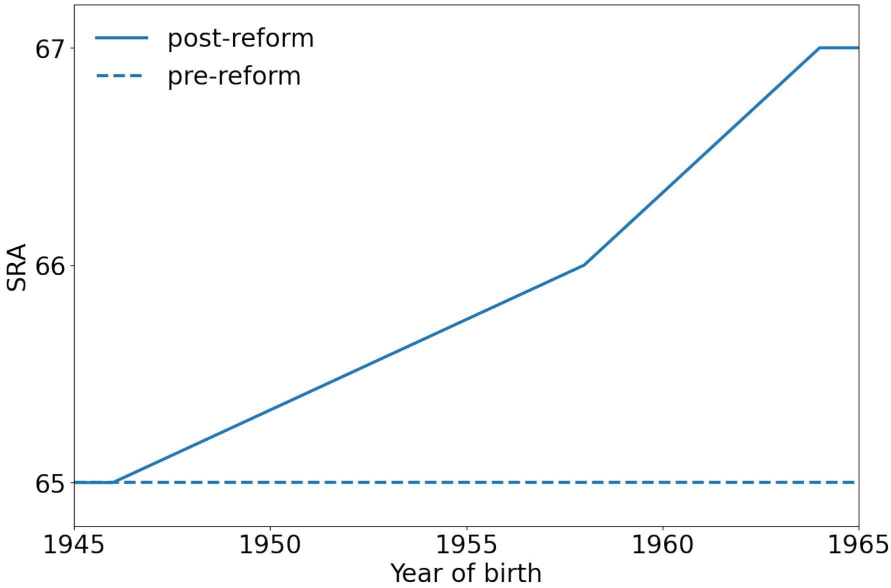
Source: German Federal Pension Insurance (Deutsche Rentenversicherung, DRV).

important type of disability-based pension can be claimed at any age if the claimant can prove reduced capacity to work. The size of these occupation-based disability pensions equals what their old-age pensions would have been if they had continued working at the same earnings level until reaching the SRA. Typically, disability pensions are subject to a penalty of three times the ERP, i.e., 10.8 percent.[16]

In 2007, a reform was passed, which gradually increased the SRA from 65 to 67 years for birth cohorts between 1947 and 1964 (cf. figure 2). To offset the erosion of replacement rates and the rise in contribution rates brought about by population ageing, there is a public debate about further increases in the SRA. For example, in 2023 the German Council of Economic Experts recommends a continued increase in the SRA by 0.5 years every 10 years (Grimm et al., 2023). This would imply an SRA of 68 years for the birth cohort of 1984 and of 69 years for the 2004 cohort.

[16]More precisely, the penalty for the ERP for every year of retirement before the SRA minus two years, capped at 10.8 percent. However, the majority of disability pensioners retire more than three years before the SRA.

Figure 2: 2007 Reform of the Statutory Retirement Age



Notes: Applicable SRA depending on birth year before and after the 2007 reform. The SRA is the reference age at which individuals can claim their old-age pensions without penalty.

2.2. Data

Our analysis relies on two main data sources, the German Socio-Economic Panel (SOEP) and the SOEP Innovation Sample (SOEP-IS). The SOEP-core is a rich and representative longitudinal household survey(Goebel et al., 2019). The SOEP-IS is a separate representative sample that is part of the SOEP infrastructure, includes the SOEP-core questionnaire, and additionally allows researchers to submit their own questions (Richter and Schupp, 2015). We elicit subjective policy beliefs from the SOEP-IS sample and use these to predict beliefs in the SOEP-core sample. We then estimate our model on SOEP-core data. In the following, we briefly describe our sample composition and restriction criteria.

Policy belief sample. In the 2022 wave of the SOEP-IS, we elicited probabilistic expectations about retirement and pension policy. Specifically, we asked respondents about their own expected pension claiming ages, as well as future development of Statutory Retirement Age and the current Early Retirement Penalty.[17] The sample consists of 798 adult individuals who are not yet retired and are representative of the German working-age population. The panel structure and availability of SOEP-core covariates allow us to account for history dependence and relevant heterogeneities when predicting beliefs in the SOEP-core sample. In section 3 we describe this in more detail.

Structural estimation sample. We estimate our structural model on data from the SOEP-core, which we link with administrative pension data to get more precise data on retirement timing (Lüthen et al., 2022). We limit the analysis to the years 2013-2020. Other sample restrictions stem mainly from model restrictions. We focus on individuals aged 30 or older who are covered by public pension insurance (cf. section 2.1). In the model, there are certain combinations of states and choices we do not allow. For instance, men cannot work part-time, and retirement

[17]See Appendix C.1 for the exact wording of the questions.

is an absorbing state, meaning that we drop individuals who report having been retired in the past and later report working again.

In addition to the structural estimation sample, we create several auxiliary samples from the SOEP core to estimate processes outside the model, such as the evolution of health over the life-cycle (cf. section 4). We do not estimate these on the structural estimation sample because data availability requirements differ. Aside from the linked SOEP data, we rely on only a few external data sources. We use CPI data to deflate nominal variables and population mortality to estimate life expectancy. These data come from the German Federal Statistical Office.

Table 1: Structural Estimation Sample Description

	Men		Women		
	High Educ.	Low Educ.	High Educ.	Low Educ.	Total
Unique Households	3,209	7,656	3,343	9,335	15,387
Unique Individuals	3,216	7,716	3,354	9,382	23,665
Observations	16,432	37,634	17,369	46,114	117,549
Share Full-time	0.695	0.568	0.347	0.207	0.412
Share Part-time	0.000	0.000	0.360	0.242	0.148
Share Unemployed	0.018	0.060	0.113	0.184	0.111
Share Retired	0.287	0.371	0.180	0.367	0.329
Share Good Health	0.850	0.736	0.847	0.734	0.767
Share Single	0.152	0.164	0.291	0.318	0.242
Average Work Experience	25.4	29.8	16.5	18.9	22.9
Average Wealth (1000 EUR)	411.7	196.7	317.9	192.3	242.9

Notes: Data from the German Socio-Economic Panel (SOEP) 2013-2020. Sample restricted to individuals aged 30 and above who are covered by public pension insurance. High education is defined as having at least a university entrance qualification (Abitur). Single is defined as not living with a partner in the same household. Work experience is measured in years since labor market entry, with a year of part-time work counted as half a year. Wealth includes all reported financial and real assets minus debts, inflated to 2020 levels, censored at 0, and measured in 1000 euros.

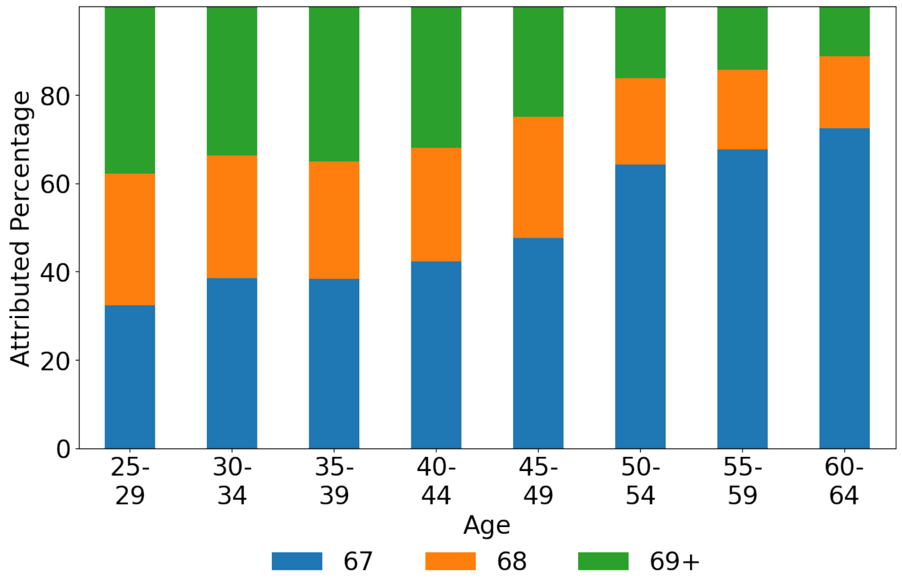
3. Policy Beliefs

We describe the elicitation of subjective policy beliefs about the German retirement system and provide formalizations to quantify their evolution over the life-cycle. Section 3.1 addresses the subjective policy uncertainty about the SRA, while Section 3.2 introduces our findings on misinformation about the ERP.

3.1. Policy Uncertainty and the Statutory Retirement Age

Figure 3 illustrates the probabilistic expectations of the SRA at the time of the respondents' expected time of retirement.[18] The results are twofold. First, respondents expect further increases in the SRA. The younger the respondents are, the higher the expected SRA. Second, the further away respondents are from their expected retirement, the larger the uncertainty. Thus, uncertainty decreases with age as policy and expectations converge over time.

Figure 3: Subjective Distributions over Future SRAs



Notes: Respondent probabilistic expectations of the SRA. Data from the 2022 wave of the SOEP Innovation Sample (SOEP-IS). Respondents were asked to attribute probabilities to different potential SRAs at the time they retire. See appendix C.1 for question wording.

We formalize the expected SRA so that the belief process retains both findings and can quantify the expected increase as well as the uncertainty of the SRA. In particular, we assume agents of age t expect the SRA to evolve according to a random walk with drift:

$$SRA_{t+1} = \alpha + SRA_t + v_{t+1} \tag{1}$$

where v_t is i.i.d. normally distributed with mean zero and constant variance σ^2_{SRA}. This formalization is similar to objective policy uncertainty in Hentall-MacCuish (2025), except that we allow for negative and non-integer shocks. This way, we can accommodate gradual reform and account for people born before 1964 who are currently subject to a non-integer SRA. As a result, at any time t before retirement, agents' expectations and associated uncertainty about the SRA at time $T \geq t$ are given by

[18] See Appendix C.1 for question wording.

$$SRA_T \sim N(SRA_t + (T-t)\alpha, (T-t)\sigma^2_{SRA}) \tag{2}$$

This model captures the key features of our survey data and abstracts from the determinants of expectation formations aside from current policy. One alternative would be to model reform expectations as a function of previous experience (Malmendier and Nagel, 2016; Kuchler and Zafar, 2019), but as such reforms are rare, we are not able to do so with our sample.[19]

To estimate the key parameters α and σ^2_{SRA} from our model, we first estimate a truncated normal distribution for each individual using their elicited probabilities. Let $E_{i,t}[t_R]$ be the individual's expected retirement age. That is the age for which we elicited probabilistic expectation of the SRA. For each observation i at age t, we can use the truncated normal distributions of their SRA to construct the subjective expectation $E_{i,t}[SRA(E_{i,t}[t_R])]$, and the subjective forecast variance $VAR_{i,t}[SRA(E_{i,t}[t_R])]$ of the SRA at their expected retirement age. This allows us to estimate α via OLS:

$$E_{i,t}[SRA(E_{i,t}[t_R])] - SRA_t = \alpha(E_{i,t}[t_R] - t) + \epsilon_i. \tag{3}$$

And σ^2_{SRA}:

$$VAR_{i,t}[SRA(E_{i,t}[t_R])] = \sigma^2_{SRA}(E_{i,t}[t_R] - t) + \xi_i \tag{4}$$

Table 2 reports our estimate for the random walk of our policy belief process. As a benchmark, the implied expected SRA increase of 0.4 years every ten years is close to the 2023 German Council of Economic Experts recommendation, which is to raise it by 0.5 years every ten years (Grimm et al., 2023).

Table 2: Expectation Process Parameter Estimates

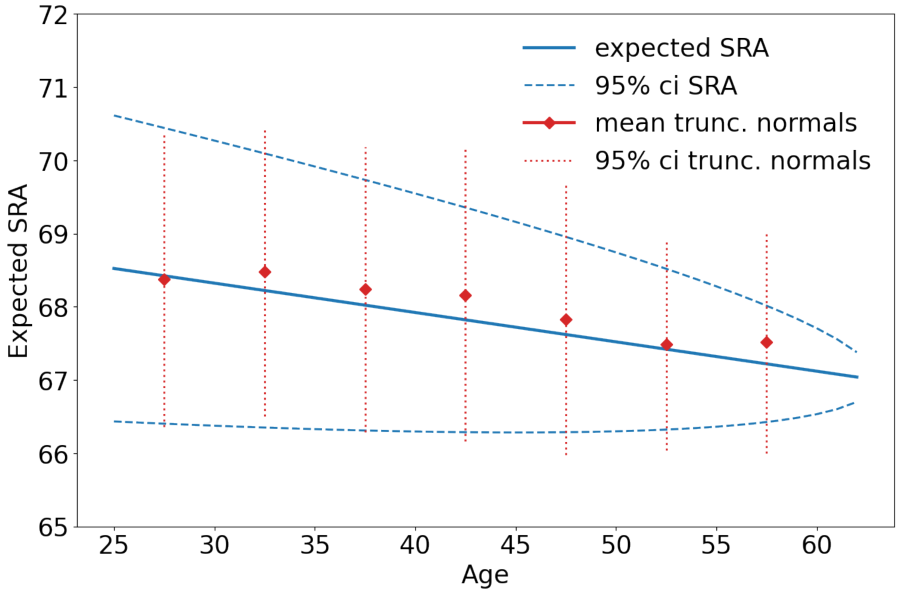
Parameter Name	Parameter	Estimate
Drift	α	0.040
		(0.0014)
Variance of Belief Process	σ^2_{SRA}	0.030
		(0.0010)

Notes: Estimates for parameters of Equation 1. Standard errors in parentheses.

Figure 4 illustrates the fit of the SRA belief process to the means and variances of the subjective probability distributions estimated for each observation. The random walk process fits the expected value well and captures the decrease of forecast variance of expected SRA towards retirement. For older cohorts, the process slightly underpredicts individual forecast variance. This suggests that some residual uncertainty remains for people close to retirement, which this model cannot fully capture.

[19] Another alternative would be to model people's expectations about factors underlying pension policy, chiefly the evolution of demographic change, and assuming some mapping from these factors to policy, as is done in Cottle Hunt (2021). Doing so based on subjective expectations would require much more survey data and strong assumptions about agents' understanding of political economy, which is why we leave it as a venue for future research.

Figure 4: Expectation Process Fit



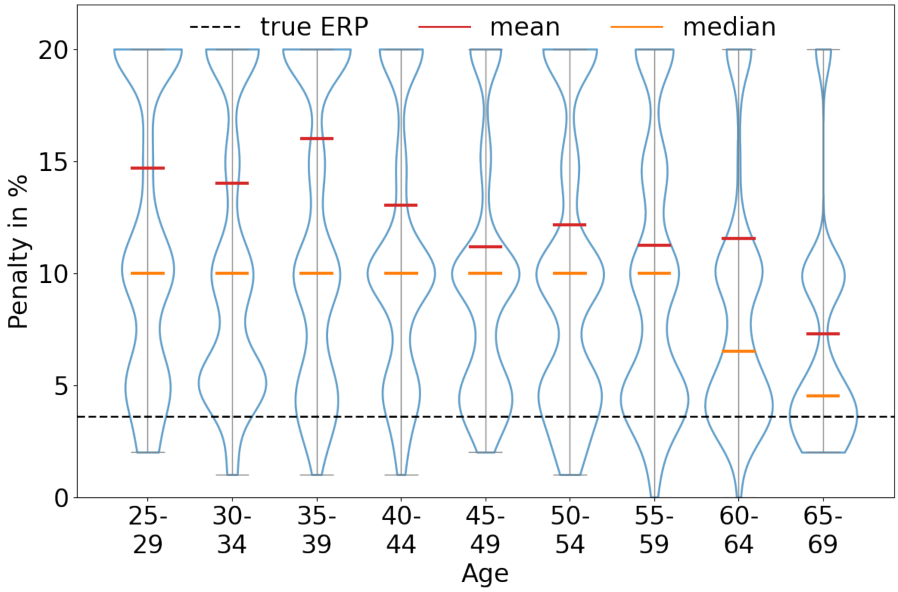
Notes: Fit of individual responses by SRA random walk (Equation 2). Individual responses are pooled by 5-year cohort. Mean and forecast variance are recovered by fitting truncated normal distributions through subjective probability distributions.

3.2. Misinformation and the Early Retirement Penalty

Figure 5 illustrates the distribution of respondents' estimates for the current Early Retirement Penalty (ERP). [20] Except for respondents in their 60s, the average belief about this number is around 12 percent across ages, while in reality, it is only 3.6 percent. The share of individuals within the five-year bins whose point estimates are close to the truth increases over time. In summary, individuals on average significantly overpredict the ERP, but the share of individuals whose responses are close to the actual ERP increases with age.

[20] See C.1 for question wording.

Figure 5: Belief about Current ERP



Notes: Respondents' beliefs about the current ERP. Distributions in the figure are censored at 20 percent (does not affect the computation of the mean and median). See appendix C.1 for question wording.

To formalize subjective beliefs about the ERP, we classify people into informed and misinformed, as Bairoliya and McKiernan (2025) do. [21] Unlike their data, however, our survey results show that misinformation rates decline notably over the life-cycle. It appears that when the ERP becomes most relevant to them, people become more informed about it. This can be interpreted as evidence in favor of rational attention models (Brown and Jeon, 2024; Hentall-MacCuish, 2025), or it may be that a lack of salience, e.g., due to social networks in which few people are already retired, causes this lack of knowledge among younger people.

We formalize the increase in the share of informed individuals over the life cycle through the evolution of a simple education-specific Markov process. The process is parameterized by a constant hazard rate λ of transitioning from misinformed to informed. We assume that the whole population is misinformed at birth.

When misinformed, we assume the agent expects a higher ERP $E\tilde{R}P$ for early retirement. This misinformation may significantly distort people's reasoning about retirement and their reactions to reforms. At its true size, early retirement is a viable option for many[22]. By contrast, if being misinformed, early retirement would be prohibitively expensive for most people.

[21] We classify as informed a respondent who answered "5" or less to the question eliciting beliefs about the current ERP. We selected this threshold so respondents to minimize the distance of responses classified as informed from the true ERP.

[22] In fact, many economists argue that 3.6 percent is too low and that the actuarially fair size should be 5-7 percent. Börsch-Supan et al. (2016).

Table 3: Early Retirement Penalty Parameter Estimates

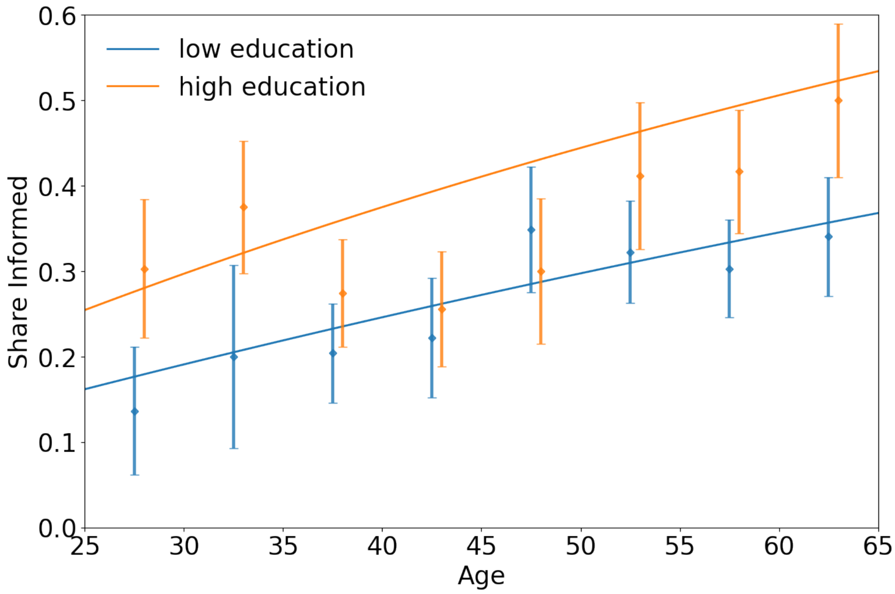
Parameter Name	Parameter	Estimates	
		Low Educ.	High Educ.
Hazard Rate	λ	0.007	0.012
		(0.001)	(0.002)
ERP Misinformed Belief	$\tilde{ERP}$	12.500	10.000
		(1.371)	(0.888)

Notes: Estimates of ERP updating process parameters from SOEP-IS. Beliefs of the misinformed are median responses, conditional on giving an answer over 5 percent. Bootstrapped standard errors in parentheses.

Table 3 summarizes the parameters of misinformation. While the share of low-educated misinformed only reduces by 0.7% per year, the high-educated are informed at a faster rate with a reduction of the misinformed share by 1.2% per year. In terms of their behavioral implication, the ERP beliefs of respondents classified as misinformed are of similar magnitude for both education groups. Although high-educated respondents who we classify as misinformed expect a penalty that is around two percentage points lower, it is still around three times the actual penalty size, making early retirement too expensive to consider under normal circumstances.

We estimate the ERP beliefs as the median subjective belief among all misinformed individuals in our sample. For the transition rates, we use a Method of Moments estimator to match 5-year cohort bin shares. We fit the increase in the share of informed individuals over the life-cycle well. Figure 6 illustrates the education-specific moments, their standard error, as well as the predicted shares.

Figure 6: Share of Informed Respondents over the Life-Cycle



Notes: Predicted and observed shares of respondents who are classified as informed about the ERP by education level. ”High education” means having at least a high school degree, which qualifies for university studies (”Abitur”).

4. Model

To study the effects of subjective policy beliefs on retirement timing, forward-looking behavior, and welfare, we formulate a dynamic life-cycle model of consumption-saving and labor supply in the tradition of French (2005). We model men and women who completed either high or low education, determining four exogenous types $\tau \in \{men, women\} \times \{high, low\}$.[23] Agents choose labor supply and savings $\{d_t, c_t\}$ to maximize the discounted sum of expected utilities over their whole life, subject to an inter-temporal budget constraint from age 30 until their stochastic death. Upon death, agents bequeath all remaining assets.

Aside from uncertainty about the future policy environment through the stochastic statutory retirement age SRA_t, agents face uncertainty from transitory wage shocks, evolution of their health h_t over the life cycle, stochastic job offers, and destruction o_t, as well as the arrival, departure, and retirement of partners p_t. In addition, agents differ in wealth a_t and work experience e_t. Together, these variables constitute the state x_t. An overview of the state, decision, and derived variables, including domain and notation, can be found in the Appendix D.1.

4.1. Work, Health, and Paths to Retirement

At every age during their lives, agents choose discrete labor supply $d_t \in \mathcal{D} = \{0, 1, 2, 3\}$ representing retirement ($d_t = 0$), unemployment ($d_t = 1$), part-time ($d_t = 2$), and full-time work ($d_t = 3$) respectively. Work experience e_t increases by one year for full-time work and 0.5 years for part-time work.[24] During their working life, agents may decide to work part- or full-time[25] if they have a job offer in the current period, i.e., $o_t = 1$. [26] Otherwise, they can always choose unemployment. In our model, retirement and pension claiming happen simultaneously, and we do not distinguish between the two decisions.

In the standard path to retirement, agents can choose to retire before the Statutory Retirement Age (SRA) but no earlier than the Early Retirement Age of 63, following a simplified version of the current German law. Note that we assume that the Early Retirement Age does not automatically change with reforms of the SRA. Early retirement incurs a permanent penalty that reduces pension benefits, known as the Early Retirement Penalty (ERP). To simplify further, we restrict decisions so that retirement is absorbing and from age 72 everyone must be retired.

Our model features the two main alternative paths to retirement beyond the standard old-age pension in Germany (cf. Section 2.1). First, agents with at least 45 years of credited periods, denoted $CP(x_t)$, may claim a *long work life pension* and retire two years before the SRA without penalties. Credited periods are predicted from the current state x_t and are not a state variable in themselves. Agents can increase their stock in credited periods by working more, generating an additional incentive to work. Any reform of the SRA would also shift the age at which they can retire on this path.

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[23] From the model solution perspective, being informed (i_t) about the early retirement penalty constitutes an additional type, since agents do not expect the penalty itself to change or their beliefs to update.

[24] We use a projection of the experience stock to the interval $[0, 1]$, following Iskhakov and Keane (2021).

[25] We allow for part-time work only for women, because few men work part-time and the decision usually is not well explained by observable data.

[26] The law of motion of o_t is described in Appendix D.2.2.

Second, agents may retire at any point in their lives and claim a *disability pension* if they are eligible. We track eligibility as a separate health state in the Markov health process h_t, in addition to good and bad health.[27] If agents claim disability pension, they pay a reduced penalty of the true ERP times the difference in their retirement age to the Early Retirement Age, but only up to a maximum of three years. If they do, the counterfactual work history is then extended to the applicable SRA for pension calculation purposes.

4.2. Income, Budget and Family Dynamics

Every period, agents choose continuous consumption $c_t \in \mathcal{C}_t = [0, a_t]$ on behalf of the household. They may consume any amount up to their assets at the beginning of the period, a_t, borrowing is not allowed, and there is no explicit consumption floor in the model. However, we assume that the welfare state always provides a basic level of income, ensuring agents can always afford a positive level of consumption. Households include a potential working-age or retired partner p_t and a deterministic number of children conditional on the agent's age, sex, education, and partner state.[28] Arrival, retirement, and separation of the partner are stochastic, and the agent does not influence them.[29]

At the end of each period, assets saved for future periods generate income at a risk-free interest rate of r. Assets evolve according to the following intertemporal budget equation:

$$a_{t+1} = (1+r)(a_t - c_t) + Y_t(d_t, x_t), \tag{5}$$

where Y_t represents total household income, which consists of own income y_t (from work or pension), potential partner income y_t^p, household level benefits $B(\cdot)$ and taxes $T(\cdot)$:

$$Y_t(x_t, d_t) = y_t(x_t, d_t) + y_t^p(x_t) + B(x_t, d_t) - T(x_t, d_t). \tag{6}$$

If the agent works, she receives an hourly wage based on accumulated work experience e_t, and an i.i.d. normally distributed shock $\zeta \sim N(0, \sigma^2_{w,\tau})$. Part- or full-time income is the product of hourly wage and the type-specific average annual hours:

$$y_t(x_t, d_t) = w_t(x_t)\, hrs(x_t, d_t), \text{ for } d_t \in \{2, 3\}. \tag{7}$$

The wage is given by

$$\ln w_t(x_t) = \gamma_{0,\tau} + \gamma_{1,\tau} \ln(e_t + 1) + \gamma_{2,\tau} \mathbb{1}\{t > 50\} + \zeta_t. \tag{8}$$

The model of wages incorporates different returns to experience by type and declining wages at old age. Investments in human capital always increase future potential wages.

When retired, agents receive a pension that increases with work experience. In Germany, pensions depend on three factors: The pension points track the contributions over the working life, the pension-point value assigns a monetary value to the stock of pension points, and the deduction factor reduces the pension in case of early retirement. As contributions are a fraction of wages, each year of experience has a different type-specific effect on the stock of

[27] We document the specification and law of motion for h_t in Appendix D.2.3.

[28] Conditional on partner presence, age, sex, and education, the number of children is deterministic and may take fractional values.

[29] The law of motion for the partner state p_t is described in Appendix D.2.1.

pension points. We, therefore, construct a function, mapping the state of an agent into pension points $PP(x_t)$. Appendix D.3.1 details how we construct this function. The pension income of an agent who retires at the SRA is then given by:

$$y_t(x_t, 0) = PP(x_t) \times PPV. \tag{9}$$

If an agent retires before the SRA at age t_R, she incurs a permanent pension reduction, denoted by ERP, for every year she retires before the SRA:

$$\begin{aligned} y_t(x_t, 0) = PP(x_t) &\times PPV \\ &\times (1 - ERP \times (SRA_{t_R} - t_R) \times \mathbb{1}(SRA_{t_R} > t_R)). \end{aligned} \tag{10}$$

In our model, an agent can be misinformed about the ERP when forming expectations. Dependent on the informed state i_t, the agent expects the following ERP:

$$ERP(i_t) = \begin{cases} E\tilde{R}P, & \text{if } i_t = 0 \\ 0.036, & \text{if } i_t = 1. \end{cases} \tag{11}$$

where $E\tilde{R}P$ is the expectation of misinformed agents.

Partner income $y_t^p(x_t)$ is determined deterministically by the agent's state. For model sparsity, we do not track any state variables, such as work experience, for the partner. In particular, the partner's income depends on the agent's age, education, and sex. Conditional on x_t, we do not model any additional uncertainty in the partner's income (Blundell et al., 2016a; Adda et al., 2017).[30] We abstract from widow and survivor pensions by assuming that after age 75 the partner state does not change anymore, implying that the partner pensions continue contributing to household income.

Household-level benefits account for the presence of a partner, the agent's own labor supply decision, and the wages of both partners. Benefits also provide transfers based on the number of children in the household, proxied by age, education, and partner state. Child benefits vary depending on whether the agent is unemployed or working. We implement a simplified tax system with income brackets, which captures the progressivity of the German tax system and the structure of social security contributions. Notably, it features joint taxation for couples. Unemployed agents are exempt from taxes or contributions, while retired agents pay taxes but only reduced contributions. Working individuals are subject to full taxation and contributions.

4.3. Preferences

In each period of their lives, agents derive flow utility that is additively separable between consumption and leisure:

$$u(c_t, d_t, x_t) = (1 + \mathbb{1}\{p_t > 0\}) \frac{(\frac{c_t}{n_t(x_t)})^{1-\mu} - 1}{1 - \mu} - L_t(x_t, d_t) + \epsilon_t(d_t) \tag{12}$$

where $n_t(x_t)$ is the consumption equivalence scale, calculated as the square root of the household size. We scale the consumption utility by the number of adults in the household and assume that men and women derive the same utility from household consumption. The term $L_t(x_t, d_t) \geq 0$ captures the disutility of work relative to retirement. This additively separable

[30]Details on the approximation of partner income can be found in Appendix D.4.1.

functional form is a simplifying assumption. However, unlike much of the literature, we estimate both men and women who make consumption choices on behalf of the household, but have different utility parameters for work. Marginal utility of consumption conditional on state should therefore not differ between sexes, which it would if utility were multiplicative instead (as in Cobb-Douglas specifications). Our specification of the utility function is most similar to Iskhakov and Keane (2021).

The disutility of work has the functional form:

$$L_t(x_t, d_t) = \begin{cases} 0, & \text{if } d_t = 0 \\ Z_L(x_t, d_t)'\kappa_{d_t}, & \text{if } d_t > 0 \end{cases} \tag{13}$$

where $Z_L(x_t, d_t)$ is a vector of choice-specific characteristics that depend on the current state, such as the number of children, education, sex, and partner state to capture joint leisure motives. The vector κ_{d_t} is the collection of corresponding choice-specific disutility parameters. The transposed vector multiplication leads to a sum of characteristic times parameter entry.

The model features choice-specific utility shocks $\epsilon_t(d_t)$, which follow an i.i.d. extreme value distribution with mean zero and scale σ_u. Extreme-value shocks are widely used in studies using discrete choice models McFadden (1973). They capture unexplained choice behavior and improve the computational feasibility of these models (Adda et al., 2017). Apart from computational reasons, we include them to reflect empirical evidence showing that many retirement decisions result from idiosyncratic shocks (Caliendo et al., 2023).

Upon death or reaching the terminal age of 100, individuals bequeath their remaining wealth and derive utility from it, represented by the following bequest utility:

$$u_b(a_T) = \vartheta \frac{a_T^{1-\mu}}{1-\mu} \tag{14}$$

where ϑ measures the intensity of the bequest motive. A strong bequest motive is a simple way to model the gradual dissaving behavior observed among retirees (Ameriks et al., 2020; De Nardi et al., 2010).

4.4. Model Solution and Beliefs

The model tracks states and decisions annually, assuming they remain constant within each year. At the start of each period, the agent fully observes their state x_t, including the realization of the taste shocks for each choice. They then decide on labor supply and consumption simultaneously. For illustrative reasons, we denote $x_t = \{\tilde{x}, SRA_t, i_t\}$, where $\tilde{x}$ collects all other states except the policy belief states.

The agent's objective is to maximize her sum of expected discounted utilities over all future periods. We denote the value of her decision problem in state x_t by $V(x_t)$. For an agent in information state $i_t = \bar{i}$, the value is the solution to the following Bellman equation:

$$V(\tilde{x}_t, SRA_t, \bar{i}) = \max_{\substack{c_t \in [0, a_t] \\ d_t \in \mathcal{D}(\tilde{x}_t, SRA_t)}} u(c_t, d_t, \tilde{x}) + \beta \, \mathrm{E}_x \left[V(\tilde{x}_{t+1}, SRA_{t+1}, \bar{i} | c_t, d_t, x_t) \right] \tag{15}$$

where c_t and d_t denote the consumption and labor supply decisions, respectively. Note that while policy states do not directly enter the flow utility, they constrain the current choice set for labor supply..

Equation (15) illustrates how beliefs are incorporated into our model and how the agent expects their evolution. For all states in $\tilde{x}$, which are probabilistic, i.e., health, partner, and job offer, we assume the agent has rational expectations about their future realizations. That is, the agent has complete knowledge about the true underlying probability distribution governing their evolution.

The agent has a probabilistic expectation about the evolution of SRA_t, which may not coincide with the actual reforms of the policy environment. Given the current SRA_t, the agent holds a probability distribution for possible SRA_{t+1}. She thinks future reforms of the SRA arise from the realizations of a random walk with drift (cf. Section 3):

$$SRA_{t+1} = \alpha + SRA_t + \upsilon_{t+1}. \tag{16}$$

However, the state SRA_t can follow a different path while she ages. Whenever the SRA changes, her expectation updates accordingly based on the new SRA state.

The agent expects to remain in her current information state, which is equivalent to not expecting the ERP to change. In contrast to her expectation, if she is classified as misinformed, she can stochastically transition to the informed state with a constant hazard rate λ every period. If a misinformed agent chooses retirement before the current SRA, the true ERP is applied.

The Bellman Equation (15) allows for solving the choice problem via backward induction and prescribes optimal policy functions for consumption and labor-supply decisions given the current state x_t. We employ the DC-EGM algorithm by Iskhakov et al. (2017) to obtain the policy functions $\pi(\tilde{x}_t, SRA_t, \bar{i})$ under subjective policy beliefs.[31]

4.5. Discussion

To build intuition for the main tradeoffs surrounding responses to SRA changes, consider an agent of age t. We abstract from the stochasticity of choices and death, i.e., there are no taste shocks, and agents live up to a deterministic age T. We maintain the stochastic evolution of other states, e.g., health, and use the same notation as before.[32] The solution to Equation (15) is a policy function $\pi(x_t)$, which maps the current state x_t into a tuple of choices $\{d_t, c_t\}$. Given an initial state x_t and a policy π, let us denote sequence of choices the agent expect to follow

$$D_t(x_t, \pi) = \{d_t^\pi, d_{t+1}^\pi, \ldots, d_{t_R}^\pi = 0, \ldots, d_{T-1}^\pi = 0\}, \tag{17}$$
$$C_t(x_t, \pi) = \{c_t^\pi, c_{t+1}^\pi, \ldots, c_T^\pi\}. \tag{18}$$

We discuss two effects of an increase in the expected SRA on the agent's choices over their life, and in particular before their retirement age t_R.

[31] The DC-EGM algorithm avoids computationally expensive root-finding for solution of the Euler equations (Carroll, 2006).

[32] Appendix D.1 provides an overview of notation.

First, SRA reforms affect permanent income (Section 4.5.1), which the household smoothes over the life cycle by adjusting labor supply and savings in the opposite direction. We show that the direct effect of an SRA increase on labor supply and savings is positive, but may be damped or even reversed by indirect effects on retirement timing.

Second, SRA reforms affect the relative attractiveness of investing in pension wealth through work versus financial wealth through savings, which governs the relative response sizes of labor supply and consumption to the reform (Section 4.5.2). We show that an SRA increase unambiguously increases the incentive to save compared to the incentive to work, and that this effect is stronger for agents who are misinformed about the ERP.

4.5.1. SRA Reform Effects on Permanent Income

Permanent income at age t is defined as the annuitized present value of expected lifetime income, that is, the constant level of consumption that could be sustained over the remaining life cycle given expected lifetime resources. Formally, permanent income is given by

$$Y_t^P(x_t, \pi) = A_T(t)^{-1}\mathrm{PV}_t(x_t, \pi) \tag{19}$$

$$= A_T(t)^{-1}\mathbb{E}_x\left[\sum_{j=0}^{T-t} R^{-j}\, Y_{t+j}(d_{t+j}^{\pi}, x_{t+j}) \;\middle|\; x_t\right] \tag{20}$$

where $\mathrm{PV}_t(x_t, \pi)$ is the expected present value of lifetime income given current state x_t and policy π, and $A_T(t) = \frac{1-R^{-(T-t+1)}}{1-R^{-1}}$ is the annuity factor over the remaining life $T - t + 1$.

We can decompose permanent income into pre-retirement and post-retirement income as

$$Y_t^P(x_t, \pi) = A_T(t)^{-1}\left(PV_t^{\text{pre}}(x_t, \pi) + PV_t^{\text{post}}(x_t, \pi)\right) \tag{21}$$

$$= A_T(t)^{-1}\Bigg(\underbrace{\mathbb{E}_x\left[\sum_{j=0}^{t_R-t-1} R^{-j}\, Y_{t+j}(d_{t+j}^{\pi}, x_{t+j}) \;\middle|\; x_t\right]}_{\text{work-life income (pre-retirement)}} + \underbrace{\mathbb{E}_x\left[\sum_{j=t_R-t}^{T-t} R^{-j}\, Y_{t+j}(0, x_{t+j}) \;\middle|\; x_t\right]}_{\text{retirement income (post-retirement, } d=0)} \Bigg) \tag{22}$$

Note that the retirement age t_R represents the first period in which $d = 0$ in the expected choice sequence $D(x_t, \pi)$, and is therefore also stochastic under policy π in x_t.

Consider an increase in the SRA by one year from the currently applicable SRA_t to $SRA_t + 1$. We denote the new state of the agent in t by x_t', which includes the new SRA state $SRA_t' = SRA_t + 1$. Let $\tilde{t}$ be the age at which the agent would have retired before the SRA increase, $t_R = \tilde{t}$. Conditional on the expected choice at $\tilde{t}$ in the new state x_t', we show the effects on the permanent income. Marginal utility smoothing then implies how the agent reacts to the SRA increase in his earlier life, i.e., what are the forward-looking behavioral responses to the increase in SRA.

If the agent does not update her decision policy π and still expects to retire at age $\tilde{t}$, the direct effect of the SRA increase is a decrease in her post-retirement income (cf. Equation (10)), which leads to a decrease in permanent income given by

$$Y_t^P(x_t', \pi) - Y_t^P(x_t, \pi) = -ERP\, A_T(t)^{-1} PV_t^{\text{post}}(x_t, \pi) < 0. \tag{23}$$

To counterbalance this loss, the agent re-optimizes her decision policy. The resulting direct effect on pre-retirement consumption is negative, while the effect on labor supply is positive.

However, indirect effects via changes in expected retirement timing may reverse this result. If the agent expects to postpone pension claiming after the increase, there are two possible cases. If the agent expects to be unemployed at age $\tilde{t}$ instead of retiring, holding other expected choices constant, the change in permanent income is given by

$$Y_t^P(x_t', \pi) - Y_t^P(x_t, \pi) = \mathbb{E}_x[Y_{\tilde{t}}(d_{\tilde{t}} = 1, x_{\tilde{t}}) - Y_{\tilde{t}}(d_{\tilde{t}} = 0, x_{\tilde{t}})|x_t] < 0. \tag{24}$$

If the income from unemployment is lower than pension benefits, the change in permanent income is negative.[33] The resulting indirect effect on pre-retirement consumption and labor supply is therefore ambiguous.

In the last case, the agent expects to be employed at age $\tilde{t}$, and the effect on permanent income is given by

$$Y_t^P(x_t', \pi) - Y_t^P(x_t, \pi) > 0. \tag{25}$$

This is straightforward as both pre-retirement income increases due to additional labor income, and post-retirement income increases due to a higher pension benefit computed at the later effective retirement age. The agent, therefore, responds to an increase in the SRA by decreasing labor supply at ages before $\tilde{t}$ and increasing consumption.

In summary, the forward-looking behavior of the agent crucially depends on their expected retirement timing and therefore on the expected SRA at retirement. This makes our model particularly suitable for studying these behavioral adjustments.

4.5.2. SRA Reform and the Substitutability of Pension Wealth and Financial Wealth

Since pre-retirement income exceeds post-retirement income, consumption smoothing behavior implies that the agent generates additional wealth to finance retirement consumption. For each euro invested at age t, the wealth at retirement a_{t_R} increases by $R^{t_R - t}$. Agents can invest by reducing their consumption and saving more.

To compare financial and pension wealth at retirement, we annuitize their values, that is, we express them as the constant consumption each wealth stock could sustain during retirement. We can express the annuity value at the time of retirement of one euro invested at age t as

$$\frac{R^{t_R - t}}{A_T(t_R)} = \frac{R^{t_R - t}}{\frac{1 - R^{-(T - t_R + 1)}}{1 - R^{-1}}}. \tag{26}$$

[33] Under certain constellations of accumulated pension points and eligibility for unemployment benefits instead of social assistance, permanent income can also increase, which generates an analogous indirect effect as working.

The annuity value decreases in t and increases in t_R. In other words, returns to investments in financial wealth are higher for younger agents and for those who expect to retire later.

Alternatively, the agent could invest in pension wealth, i.e., the future discounted value of pension payments at time t_R. Consider first an agent who expects to retire without penalties at $t_R = SRA_t$. If she works full-time instead of being unemployed in period t, she increases her pension in any period $\hat{t} \geq t_R$ by

$$\Delta y(x_{\hat{t}}, 0) = PPV \times PP(x_t, d_t = 3). \tag{27}$$

For example, if she earns exactly the average wage, $PP(x_t, d_{t-1} = 3) = 1$, in which case, in our calibrated model based on 2020 values, her annual pension would increase by $PPV \approx 408$ euros.[34] To increase her annuitized financial wealth at retirement by this amount, she would have to save around 4180 euros if she is 50 years old and expects to retire at 65, or 3600 euros if she is 50 and planning to retire at 67.[35] Therefore, an increase in the SRA, which delays expected retirement timing t_R, makes financial wealth a more attractive way to finance retirement consumption, compared with pension wealth.

If we relax the assumption of retirement without penalties and assume that the delay in retirement timing is less than the increase in the SRA, this effect does not necessarily become weaker. In this case, the agent's expected early retirement penalty would rise, making each additional year of work count less toward her pension. That would create an additional incentive to finance retirement consumption through financial wealth rather than pension wealth.

Last, consider agents classified as misinformed, who overestimate the early retirement penalty. This substitution from pension wealth to financial wealth after an increase in the SRA is unambiguously stronger for them than it is for the informed. Either their larger perceived penalty leads them to delay retirement substantially, increasing the annuitized value of financial wealth.Or, if they delay claiming by less than the SRA increase, the expected penalty rises more sharply than for informed agents, making pension wealth less attractive.

5. Estimation

For the parametrization of the model, we distinguish between three sets of parameter values. The first set is calibrated using external data sources and established literature estimates. This includes policy parameters that are assumed to remain constant within the model (e.g., tax brackets), as well as standard parameters such as the interest rate r, the discount factor β, and the inter-temporal elasticity of substitution μ. The interest rate is set to $r = 0.03$, the discount factor $\beta = 0.98$, and the inter-temporal elasticity of substitution $\mu = 0.8$.

The second set of parameters is estimated in a first step on the data, outside of the model. The estimates and corresponding estimation strategies are detailed in the appendix. They include transition probabilities for partner status (D.2.1), health and mortality (D.2.3), and job destruction (D.2.2). Additionally, the set comprises wage parameters, such as the return to

[34] This example abstracts from the indirect effect on pension wealth from the increase in future wages due to the increase in experience.

[35] Based on a life expectancy of 83 years and an after-tax risk-free rate of return of 2.25 percent.

experience and the variance of income shocks (D.4). As described in Section 3, we also estimate the policy belief and misinformation parameters separately and use them to parameterize the model.

We obtain the third set of deep structural parameters governing the labor supply decision by estimating the model with maximum likelihood following Rust (1994). In the following, we describe the estimation procedure, report the estimates of the structural parameters, and show how our model fits the data.

5.1. Structural Estimation

Identification. We estimate two different groups of deep structural parameters in the model with maximum likelihood. First, we estimate the structural disutility parameters governing the utility reduction of each choice in comparison with retirement (Equation (12)). These are identified by observations, for which we observe the job offer status in the data. We observe the job offer status for all individuals who were either working or were fired in the preceding year.

Second, we structurally estimate the parameters determining the transition probabilities for (partially) unobserved state variables. In the data, we observe whether individuals transition to employment after being unemployed the previous year, but not whether they reject a job offer. Job offer probabilities are identified by the observed decisions of the unemployed, conditional on the identification of disutility parameters. Similar to job offers, we do not observe disability pension eligibility and instead only observe take-up. Parameters that govern this transition are identified conditional on disutility parameters.

Likelihood. Formally, we can derive the likelihood function as follows: Let $\mathcal{M}$ denote the dataset of observed states and choices. It contains for each observation their labor supply decision d_k and their observed states. In the following, we denote an agent's state, excluding the taste shock's realization, which we do not observe, by x_k. The likelihood of a fully observed state x_k and decision d_k is given by the choice probability of d_k (Rust, 1987). As the choice-specific taste shocks $\epsilon_k(d_k)$ are assumed to be i.i.d. extreme value distributed and enter the utility function additive separable, the choice probabilities have a closed form solution (McFadden, 1973). Therefore, the probability to observe choice d_k in state x_k, is given by:

$$P(d_k|x_k) = \frac{\exp\{V(d_k|x_k)\}}{\sum_{d\in\mathcal{D}} \exp\{V(d|x_k)\}} \tag{28}$$

where $V(d_k|x_k)$ is the conditional value function given by

$$V(d_k|x_k) = \max_{c_t}\{u(x_k, d_k) + \mathbb{E}[V(x_{it+1})]\} \tag{29}$$

Policy beliefs about future SRA evolution enter the value function through the expectation of future states. These beliefs parameterize the value function and thus the choice probabilities and likelihood contributions. Maximum likelihood estimation allows us to directly use the beliefs, without imposing additional assumptions on realized policy regimes. This is a clear distinction from an alternative method of the simulated moment estimator, where simulation from the model would require direct assumptions about the evolution of the policy environment.

Additionally, agents differ in the knowledge of the ERP, captured by the information state i. We do not observe i in our dataset $\mathcal{M}$. Agent do not expect their information state to change, so the value function only depends on the current information state. We use our survey evidence from the SOEP-IS to predict agent-specific information probabilities $G_k(i)$. The choice probability of an observation k, where all other states are observed, is formally given by:

$$\sum_i P(d_k|x_k, i) * G_k(i) \tag{30}$$

In the SOEP-Core, we do not observe the job offer and disability eligibility state.[36] Let

$$\pi_o(o_k = 1|x_k) = \Lambda_o\Big(Z_o(x_k)'\phi_o\Big) \quad and \quad \pi_h(h_k = 2|x_k) = \Lambda_{dis}\Big(Z_{dis}(x_k)'\phi_{dis}\Big) \tag{31}$$

be the probabilities of receiving a job offer conditional on being unemployed last period and of being disability pension eligible, conditional on having experienced a bad health shock in this period. Then the probability of choosing d_k of an observation k in state x_k, where we do not observe a job offer and disability pension eligibility, is given by:

$$\sum_o \sum_h \sum_i P(d_k|x_k, i) G_k(i) \pi_o(o|x_k) \pi_{dis}(h|x_k) \tag{32}$$

The likelihood function is then a composition of separate likelihoods, where we observe the state fully or do not observe disability pension eligibility and the job offer.[37] The log likelihood of all states where we fully observe x_k, including h_k and o_k is given by:

$$\mathcal{LL}_{fo} = \sum_k \log\Big(\pi_h(h_k|x_k)\pi_o(o_k|x_k) \sum_i P(d_k|x_k, i) * G_k(i)\Big) \tag{33}$$

and the log likelihood of states x_k, where we do not observe both h_k and o_k is given by:

$$\mathcal{LL}_{uo} = \sum_k \log\Big(\sum_o \sum_h \sum_i P(d_k|x_k, i) * G_k(i)\pi_h(h|x_k)\pi_o(o|x_k)\Big). \tag{34}$$

We estimate the deep structural parameters θ by

$$\hat{\theta} = \arg\max LL(\mathcal{M}, \theta) \tag{35}$$

$$= \arg\max LL_{fo}(\mathcal{M}, \theta) + LL_{uo}(\mathcal{M}, \theta) \tag{36}$$

and use Gabler (2022) with the limited-memory Broyden–Fletcher–Goldfarb–Shanno algorithm (Virtanen et al., 2020) to maximize the log-likelihood. We use the algorithm's approximation of the inverse Hessian to obtain standard errors of the estimates.

5.2. Estimation Results and Model Fit

After parametrizing the model with the estimates from the literature and our first step estimation, we use maximum likelihood to estimate the disutility parameters of our model (cf. equation 13), the job offer probabilities and the parameters governing the disability probabilities.

[36] We assume that individuals in good health can never be eligible for disability.

[37] The case where we observe disability pension eligibility or the job offer follows directly.

Table 4 reports our estimates of the disutility parameters.We observe differences in how health and financial incentives affect men and women. Agents prefer unemployment to work; otherwise, given stronger financial incentives for work, no one would be unemployed. For agents in bad health, the difference in the disutility of unemployment and work is higher than for agents in good health. Working in bad health is therefore less attractive than working in good health. Interestingly, a retired partner has a positive incentive for men also to retire, whereas this is not the case for women. This finding aligns with the results of previous studies that retirement incentives for husbands do not affect the retirement decisions of wives (Coile, 2004).

Table 4: Disutility Parameters

Parameter Name	Estimates	
	Men	Women
Unemployed; Bad Health	1.0531	0.5272
	(0.2924)	(0.2439)
Unemployed; Good Health	1.1251	0.6701
	(0.2241)	(0.2031)
Full-time; Bad Health	1.9038	1.5719
	(0.0169)	(0.0078)
Full-time; Good Health	1.7271	1.5962
	(0.1920)	(0.0098)
Part-time; Bad Health		1.0483
		(0.1416)
Part-time; Good Health		1.0850
		(0.2353)
Children; Part-time; Low Education		0.1217
		(0.0105)
Children; Part-time; High Education		0.0000
		(0.0105)
Children; Full-time; Low Education		0.2182
		(0.0193)
Children; Full-time; High Education		0.0794
		(0.0124)
Partner Retired	-0.4469	0.0000
	(0.3077)	(0.0071)

Notes: Maximum likelihood estimates of additive separable utility from labor supply choice. Standard errors in parentheses.

Table 5 reports logit parameters of the job offer process (cf. Appendix D.2.2). We document a negative age trend in job offers, consistent with estimates from similar contexts in the literature. For the disability probability, we see the reversed age trend in Table 6.

Table 5: Job Offer Parameters

Parameter Name	Estimates	
	Men	Women
Constant	-0.7910	-1.4881
	(0.0610)	(0.0647)
High Education	0.7991	0.8371
	(0.0718)	(0.0488)
Age Above 50	-0.1357	-0.3399
	(0.0323)	(0.0262)
Age Above 55	-0.1091	-0.0784
	(0.0400)	(0.0303)
Age Above 60	-0.6820	-0.4856
	(0.0440)	(0.0439)

Notes: Maximum likelihood estimates of the logit parameters governing the job offer probability for an unemployed agent. Standard errors in parentheses.

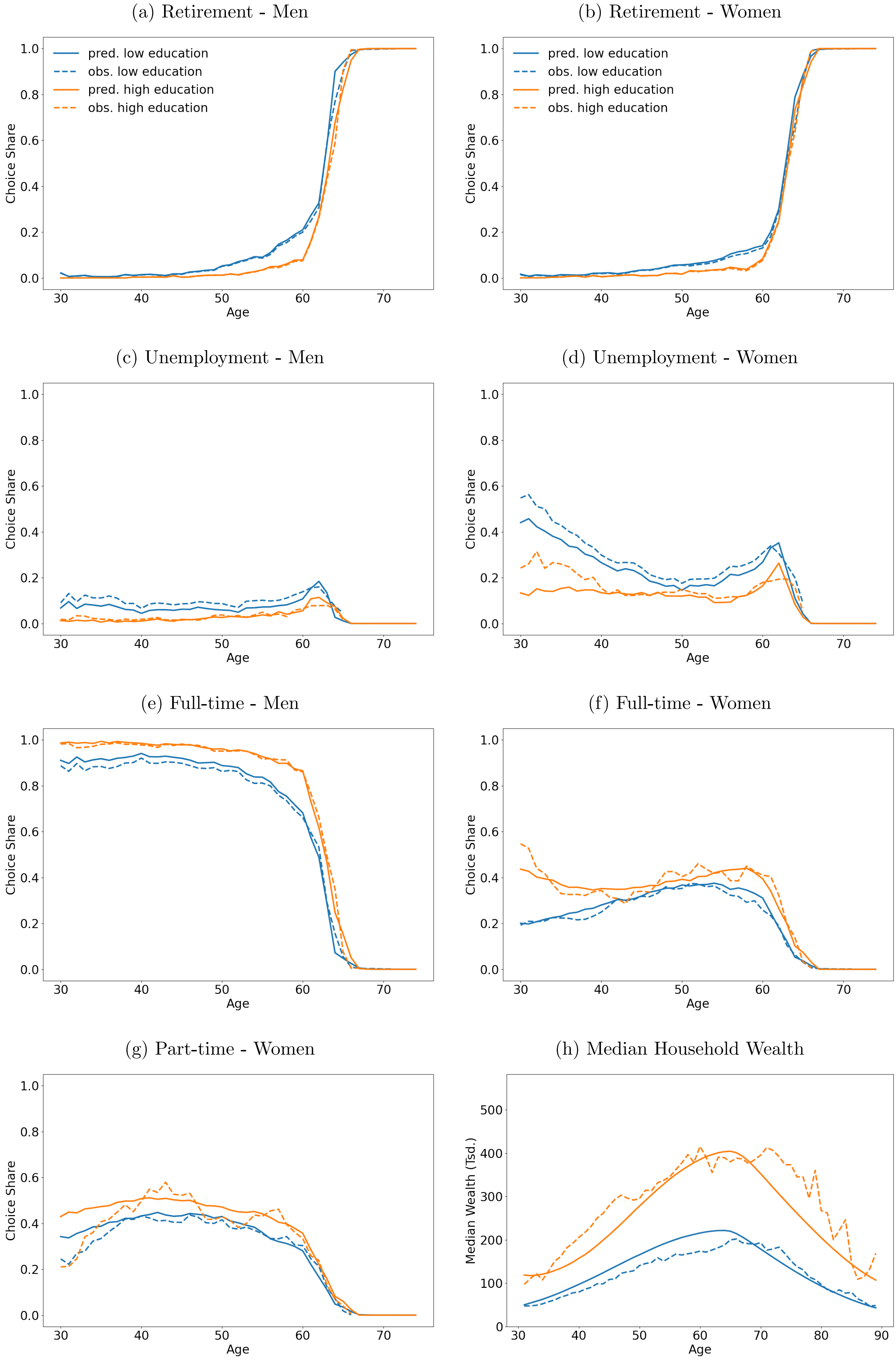
Table 6: Disability Probability Parameters

Parameter Name	Estimates	
	Men	Women
Constant	-4.2043	-4.0418
	(0.0333)	(0.0173)
Age Above 50	0.2031	0.9165
	(0.0157)	(0.0107)
Age Above 55	0.9816	0.4499
	(0.0274)	(0.0169)
Age Above 60	0.9572	0.5944
	(0.0217)	(0.0108)

Notes: Maximum likelihood estimates of the logit parameters governing the disability probability. The probability of disability is conditional on being in poor health. Standard errors in parentheses.

Figure 7 shows the fit of our estimated model to the data for men (left panel) and women (right panel), as well as the untargeted wealth fit. We construct the figure by solving the model with estimated parameters and computing choice probabilities for each observation. The observed choice shares are directly calculated from the observed choices, while the predicted ones are the average choice probabilities of all observations at a particular age. Our model accurately predicts the labor supply choices and retirement patterns across sexes and education groups. If we simulate life-cycles instead and draw the initial conditions from observed distributions, choice patterns look similar. This gives credence to the results of our counterfactual policy simulations.

Figure 7: Model Fit - Choice Shares and Household Wealth



6. Results

In this section, we use the estimated model to analyze the effects of subjective policy beliefs through counterfactual simulations. In each simulation, we make specific assumptions about the future evolution of the policy regime and the agents' policy beliefs. In our *benchmark model*, agents hold policy beliefs characterized by uncertainty and misinformation, as detailed in Section 3. The policy regime always starts at an SRA of 67 years, as the current German law prescribes, and we consider different scenarios for future increases.

Outcomes we examine are individual labor supply, annual household savings, financial wealth, pension wealth, and individual welfare. We report annual labor supply in hours as a way of aggregating discrete choices.[38] We report annual labor supply and savings separately for agents' "work lives", i.e., the time before agents turn 63 and can first retire without qualifying for disability pension. Pension wealth is the present value of an agent's expected future pension payments.[39] For the welfare analysis, we follow Low et al. (2010) and compute compensating variations: the percentage change in consumption in each period needed to make agents indifferent between scenarios. (refer to Appendix E.1 for details).

In Section 6.1, we analyze how policy beliefs moderate reform effects on individual behavior and welfare. In Section 6.2, we analyze the effects of an information treatment that eliminates misinformation about the ERP.

6.1. Retirement Age Reforms and the Role of Policy Uncertainty

6.1.1. Behavioral Responses

We start by studying the effects of a two-year increase in the SRA from 67 to 69 years. Table 7 summarizes the results. Columns (1) and (2) contain our benchmark results. We observe that this two-year increase in the SRA delays average actual retirement (excluding disability pensions) by 0.85 years. Due to the reduction in time spent in retirement, agents need to accumulate less wealth to finance old age consumption. As a consequence, over the "early" working life (below age 63), both labor supply and savings decrease as a response to the reform.

Despite the delay in retirement, the shorter pension payout period, and the increase in average penalties for early retirement, result in a considerably larger drop in pension wealth compared to financial wealth at retirement (-6.16 percent vs. -1.78 percent). Agents do not increase labor supply at younger ages to make up for this loss in pension income, which reflects the fact that the reduction in system generosity makes pension wealth a less attractive investment compared to financial wealth (cf. Section 4.5). Yet, due to the increase in old-age labor supply, the effect on total lifetime labor supply is positive (+1.48 percent).

To isolate the effects of probabilistic reform expectations, we simulate the same reform for agents without policy uncertainty. That means, agents know already with certainty at age 30 what the SRA will be when they retire. We estimate that the effect on retirement timing is

[38] Since we only allow for limited reactions at the intensive margin, these largely reflect probabilities that agents quit jobs or accept job offers. For women, this measure includes switching between part-time and full-time work.

[39] This does not include the expected present value of her partner's pension wealth, because it is exogenous in our model.

identical. Agents postpone claiming their pension by around 0.85 years. However, the effects in the early work life responses are larger. With perfect foresight, agents adjust labor supply by -0.32 percent (compared to -0.16 percent with uncertainty) and savings by -2.25 percent (compared to -1.74 percent). As a result, the total effect on labor supply, i.e., the effect that includes the delay in retirement timing, is larger with uncertainty than it would be without it.

Table 7: Effects of a two-year SRA increase

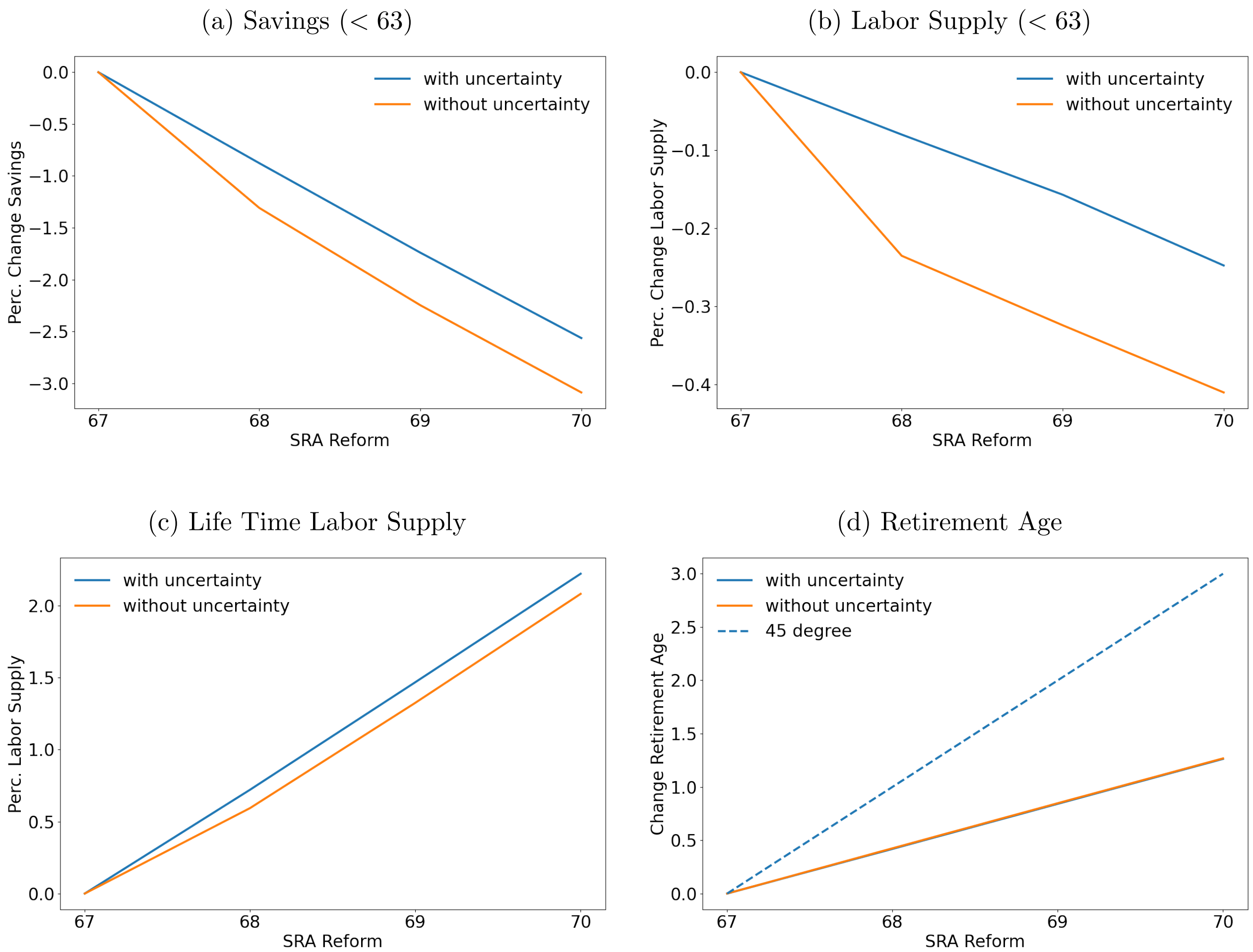
Outcome	Uncertainty			No Uncertainty		
	SRA 67 (1)	SRA 69 (2)	Diff. % (3)	SRA 67 (4)	SRA 69 (5)	Diff. % (6)
SRA						
True SRA	67.00	69.00		67.00	69.00	
Expected SRA	68.32	68.32		67.00	69.00	
Retirement						
Retirement Age	65.98	66.83	+1.28	65.98	66.83	+1.28
Pension Wealth	192.02	180.18	-6.16	192.53	180.42	-6.29
Financial Wealth	257.05	252.48	-1.78	258.58	253.24	-2.07
Work Life (< 63)						
Annual Labor Supply (hrs)	1417.97	1415.74	-0.16	1422.51	1417.89	-0.32
Annual Consumption	38.23	38.28	+0.15	38.24	38.29	+0.13
Annual Savings	4.60	4.52	-1.74	4.65	4.55	-2.25
Lifecycle (30+)						
Annual Labor Supply (hrs)	919.05	932.55	+1.47	921.68	933.90	+1.33
Average Financial Wealth	155.94	155.97	+0.01	156.87	156.51	-0.23

Notes: Behavioral responses to an SRA increase from 67 to 69 for agents with and without uncertainty. Pension wealth is calculated as the annuitized stream of expected pension income until the expected end of life. Pension and financial wealth are expressed in thousand euros at the time of retirement. Expected SRA is the expectation of a 30 year 30-year-old at age 63, while true SRA is the true policy regime at retirement.

We conclude that uncertainty weakens forward-looking reform responses. Although uncertainty disorts individual behavior, this distortion is beneficial from a policymaker's perspective. Uncertainty strengthens the intended total reform effect on labor supply, while the unintended side effect of reduced provisional savings is mitigated. We study welfare consequences of this distortion in the next subsection.

To demonstrate that the finding of attenuated life-cycle responses is not an artifact of this specific reform, we repeat the analysis for different SRA increases up to 70 years. Figure 8 illustrates the results. We observe that the finding of attenuated life-cycle responses due to uncertainty remains robust. Early life-cycle reactions to SRA reform are attenuated by approximately 20 percent for savings and up to 50 percent for labor supply. Meanwhile, no significant difference can be observed in the effects of reforms on retirement timing. An additional year of SRA delays the average retirement timing by around 0.4 years, consistent with observed reform effects in the literature. As a result, reforms boost lifetime labor supply by around 10 percent more than they would have if agents had perfect foresight.

Figure 8: Reform Effects with and without Uncertainty



Notes: Responses to SRA reforms in comparison to baseline scenario, where SRA remains at 67. Effects are calculated as differences to separate baselines, including policy uncertainty or without uncertainty.

6.1.2. Welfare analysis

Table 8 presents the analysis of individual welfare effects of SRA reforms. We calculate compensating variations, i.e., adjustment of life-cycle consumption [40] that would make agents indifferent with the case in which SRA remains at 67.

In our benchmark model, for each year of increase, the welfare loss is approximately 0.23 percent and evolves linearly with SRA increases. We conduct the same analysis again for agents with perfect foresight and no policy uncertainty to parallel the previous analysis of behavioral responses. The resulting welfare losses of per year of SRA increase are virtually the same, suggesting policy uncertainty about the headline SRA has no substantial effect on individual welfare.

Since we define policy uncertainty as probabilistic expectations of the SRA, this raises two questions. First, younger agents in the benchmark simulation initially predict an SRA of 68.3, when in fact the eventual SRA is a different number, so why does this not distort behavior enough to cause a welfare loss? Second, why does forecast variance not influence welfare? At

[40] See Appendix E.1 for details.

age 30, the standard deviation of expected SRA at retirement is around one year, meaning agents consider much larger SRAs to be possible. Standard theory predicts that they should build precautionary savings to hedge against this risk.

The main answer is that both misprediction and forecast variance are the strongest at young ages, when the behavioral reform responses we observe are the smallest. At later ages, agents gradually update their beliefs and readjust. In the years leading up to retirement, where largest reform responses are observed, the remaining uncertainty becomes very small. While the behavioral distortions we observed from policy uncertainty matter in the aggregate, they are small enough from an individual perspective for their welfare effects to be negligible.

Table 8: Welfare Differences of SRA Reforms

Group	SRA 67	SRA 68	SRA 69	SRA 70
Whole Sample				
Benchmark: Uncertainty	0.00	-0.23	-0.46	-0.68
No Uncertainty	0.00	-0.23	-0.45	-0.68
By Initial Information				
Initially Informed	0.00	-0.16	-0.33	-0.49
Initially Misinformed	0.00	-0.25	-0.50	-0.74
By Type				
Low Edu Men	0.00	-0.37	-0.73	-1.10
High Edu Men	0.00	-0.24	-0.50	-0.73
Low Edu Women	0.00	-0.19	-0.37	-0.55
High Edu Women	0.00	-0.12	-0.25	-0.39

Notes: Welfare differences of SRA reforms calculated as compensating variations in percent. The difference is calculated in comparison to the baseline scenario of SRA 67 in each group.

Table 8 illustrates heterogeneity in welfare losses across groups in our benchmark model. For agents who are initially misinformed about the ERP, the welfare loss is around 50 percent larger than for informed agents. For the misinformed, raising the SRA gives the agent fewer possibilities to adjust, as early retirement with penalties is a large response margin, as seen in the previous section. This leads to larger behavioral distortions and, therefore, larger welfare loss.

If we split our simulation sample by sex and education, we see that welfare losses are larger for men and for the low educated. This is because the more important pension wealth is to an individual's old age consumption financing, the larger the welfare loss of a pension reform becomes. The low educated have lower wages and partners with lower wages, on average. This means that it is more difficult for them to substitute from pension wealth to financial wealth by reducing working life consumption. Men, on average, have higher pension claims, meaning that a reduction in pension generosity leads to a higher decline in pension wealth for them if they do not postpone retirement. Thus, their behavior is more distorted, resulting in larger welfare losses.

Due to the difference of policy beliefs and actual policy in our model, we can compare expected (*ex ante*) and realized (*ex post*) welfare effects of the reform. Table 9 presents the results. We evaluate an increase of the SRA by 1.32 years, exactly matching the point prediction of 30-year old agents with a current SRA of 67. For the initially informed, the only difference between ex ante and ex post is that in the ex ante simulation of agent expectations, the SRA evolves stochastically and only moves to 68.32 on average. For the misinformed, the two simulations further differ in that the true ERP is applied for early retirees only in the ex post simulation, and in that beliefs are updated randomly according to the information process described in Section 3.2.

In line with our previous results, the difference is only marginal for the initially informed. For the misinformed, however, the expected welfare loss differs markedly from the realized one. Ex-ante, they overestimate the welfare effect of the SRA increase by around half (-0.54 percent in expectations vs. -0.33 in realization, compared with no SRA increase). This happens for two reasons, one mechanical and one related to re-optimization after belief updating.

Mechanically, when a misinformed agent retires early despite overestimating the ERP, she pays only the actual deduction of 3.6 percent per year of early retirement and thus receives a higher pension than she expected, which decreases the realized welfare loss of the reform. Furthermore, random belief updating implies that there is a good chance that, sometime before retirement, she learns about the true ERP and reoptimizes her behavior accordingly. The finding that misinformation leads to overestimation of the welfare cost of SRA increases has implications both for the political economy of policy reform and for its normative evaluation from a social planner perspective.[41]

Table 9: Ex Post vs. Ex Ante Welfare

	SRA 67	SRA 68.32
Full Sample		
Ex post	0.00	-0.31
Ex ante		-0.47
Initially Informed		
Ex post	0.00	-0.21
Ex ante		-0.22
Initially Misinformed		
Ex post	0.00	-0.33
Ex ante		-0.54

Notes: Welfare difference ex-ante in expectation vs. realized ex post.

Finally, it should be noted that we present effects from a partial equilibrium model, evaluating a reform that is not fiscally neutral. Since the reform increases government revenue as well as aggregate labor supply, general equilibrium feedback effects can be expected to counteract the negative effects of the reform on individual welfare.

[41]Which welfare criterion is the appropriate one to evaluate policies which are perceived as risky by agents ex ante is subject to debate, as discussed for example in Fleurbaey (2010).

6.2. De-Biasing and the Puzzle of Retirement Bunching

6.2.1. De-Biasing

A natural question in a model with biased expectations is what would happen if the bias were eliminated. The purpose of this counterfactual exercise is to uncover the effect of misinformation on individual behavior and welfare, both at the margin of retirement timing and over the lifecycle.

We again simulate the life cycles of a representative cohort of 30-year-old agents, in which the true SRA remains at 67 years. The baseline simulation is our benchmark model with uncertainty and misinformation, meaning the majority is initially misinformed[42] and gradually updates their beliefs according to the estimated Markov transition process. In the counterfactual, everyone is correctly informed about the ERP from age 30 onward. Table 10 summarizes the results.

Table 10: Effects of Removing Early Retirement Penalty Bias

Outcome	Baseline with Misinformed	Only Informed	Difference (%)
Work Life (< 63)			
Annual Labor Supply (hrs)	1417.97	1407.27	-0.75
Annual Consumption	38.23	37.96	-0.70
Annual Savings	4.60	4.97	+8.17
Retirement			
Retirement Age	65.98	64.85	-1.72
Pension Wealth	192.02	186.28	-2.99
Financial Wealth	257.05	271.49	+5.61
Lifecycle (30+)			
Annual Labor Supply (hrs)	919.05	889.98	-3.16
Average Financial Wealth	155.94	160.72	+3.06
Welfare			
Compensating Variation (%)			+0.16%

Notes: Behavioral responses to information treatment that eliminates ERP bias. In *Baseline* scenario, agents are partially misinformed about the ERP and learn over time. In *Only Informed*, everyone is informed from age 30. Monetary quantities in 1000 Euros.

Eliminating the bias has strong behavioral effects. Intuitively, removing the Early Retirement Penalty overestimation significantly shifts retirement timing. Excluding agents who claim a disability pension, the average pension claiming age is reduced by 1.13 years. Because agents now on average expect to retire with sizable penalties, when without the debiasing most expect to retire at the SRA, the value of investing into pension wealth through work decreases relative to investing in financial wealth through savings (cf. Section 4.5). During their working lives, agents on average work slightly less (-0.75 percent) and increase savings significantly, by around 8.17 percent.

[42] 65 to 73 percent, depending on education type, cf. Figure 6

As a result, debiasing leads to a large drop in lifetime labor supply by around 3.16 percent, for a surprisingly modest welfare gain of 0.16 percent. Both results are driven by men — especially low-educated men — who are most likely to be the main income earners in the household and would under hardly any circumstances consider early retirement when facing high penalties (cf. Section 6.1.2).

6.2.2. Retirement Bunching Puzzle

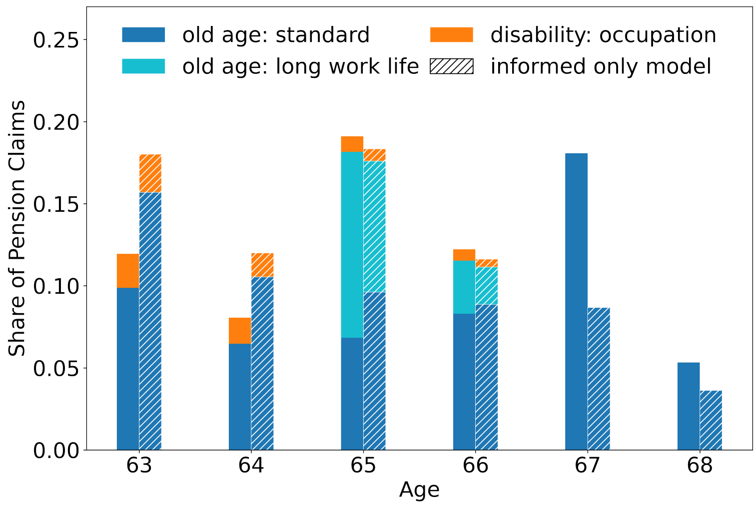
In the previous exercise, we used our benchmark model and eliminated the bias, simulating the effects of an information treatment policy. In the following, we switch the perspective to that of a researcher and observe retirement behavior in our benchmark model compared to a *re-estimated* model without any misinformation about the ERP. Figure 9 illustrates the results.

We observe that in our benchmark model, the well-known spike of claiming decisions at the SRA emerges for the standard old-age pension, while in the alternative model without misinformation, old-age pension claiming evolves smoothly around the SRA. The reason is intuitive. People on average would prefer to retire before the SRA, but misinformed agents consider early retirement prohibitively expensive, so they postpone it until the SRA.[43] Like Hentall-MacCuish (2025), we show that a misperception of the policy environment can produce bunching of retirement decisions, which has explained by other other behavioral mechanisms.

The most prevalent explanations for retirement bunching are the SRA working as a norm, or as a reference point for the appropriate time to retire (Behaghel and Blau, 2012; Cribb et al., 2016; Gruber et al., 2022; Lalive et al., 2023; Seibold, 2021). Misinformation in our model is similar in the sense that people believe that there is a cost to deviating from the intended timing of retirement set by the SRA. However, here the perceived cost is financial rather than psychological. Although these explanations have similar observational implications, their policy implications differ, as discussed in the conclusion. Cleanly identifying how much the different motives drive behavior will therefore be fruitful, but is beyond the scope of this study.

[43] Examples include low-income singles whose pension claim is so low that they will rely on social assistance anyway, or people in bad health with very low pension claims—usually women with short employment histories—who expect to live off financial assets and spousal income during retirement.

Figure 9: Misinformation and Retirement Bunching



Notes: Age at retirement, by type of pension, as a share of the population. Shaded bars are from a re-estimated model without misinformation about the ERP. The SRA is 67. "Long work life" pensions are available without penalties for agents with at least 45 credited periods, at a minimum age of 67.

7. Conclusion

This paper quantifies how subjective policy beliefs shape behavioral responses to pension reform. We develop and estimate a structural life-cycle model in which forward-looking agents have imperfect information about the future policy regime. In particular, they are uncertain and misinformed about the features of the future policy beliefs that govern the optimal timing of retirement. Agents hold probabilistic expectations about the future Statutory Retirement Age (*uncertainty*) and systematically overestimate the penalty for early retirement (*misinformation*). Using survey-elicited beliefs from the German SOEP, we estimate the model and simulate counterfactual policy scenarios.

We discuss how the effects of SRA reform depend critically on their indirect effects on retirement timing. Reducing welfare state generosity, particularly old-age benefits, is usually expected to boost labor supply and savings far from retirement. Since Feldstein (1974), it is understood that these effects may be reversed when retirement timing is endogenous. The expected relative length of time spent in retirement, compared to time spent in the labor market, is key. Full-information models may fail to capture true expectations about time spent in retirement, with potentially strong implications for the reform effects they predict. This point is illustrated by the growing literature about subjective mortality beliefs and their effects on pension reform (Bairoliya and McKiernan, 2025; de Bresser, 2024).

Our results suggest that both uncertainty and misinformation support policy objectives. We show that an SRA increase with policy uncertainty generates larger labor supply gains than a reform under perfectly credible policy commitment would. Interventions eliminating misinformation would substantially reduce old-age labor supply. Although misinformation reduces individual welfare, this loss may be offset by positive aggregate effects from higher labor supply. These findings challenge the conventional wisdom that imperfect information is purely distortionary.

Our findings further show that misinformation is one way to explain retirement bunching around the SRA. Like other explanations of the phenomenon, misinformation about the ERP is consistent with the belief that 'one is not supposed to retire early'. Regardless of whether retirement bunching stems from misinformation, reference points, or normative signals, all these explanations predict stronger expected retirement responses to SRA reform than standard models. However, they have different implications for policymakers who may wish to sustain this effect. Other explanations imply that policymakers should emphasize the SRA as a *normal* retirement age, and highlight the *full* pension available at that age (Giupponi et al., 2024).

A concerning aspect of the penalty overestimation explanation is that it may be interpreted as prescribing further obfuscation of the fact that deviation from retiring at the SRA is, in fact, financially viable. A more positive interpretation would be that the strong effect of the SRA on retirement timing could be preserved by raising *actual* penalties while strengthening targeted safeguards such as health-based alternative paths to retirement. Ultimately, cleanly identifying which mechanisms drive expected retirement behavior remains an important avenue for future research.

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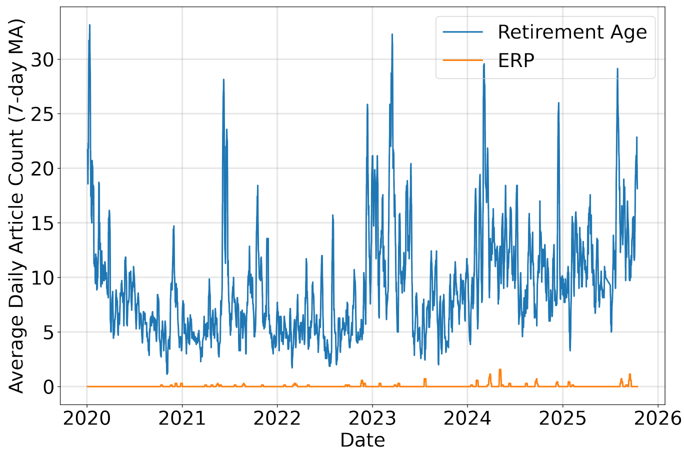
A. Appendix to Introduction

A.1. Media Analysis – Pension Debate in Germany

Figure 10: Replacement Rate and Contribution Rate

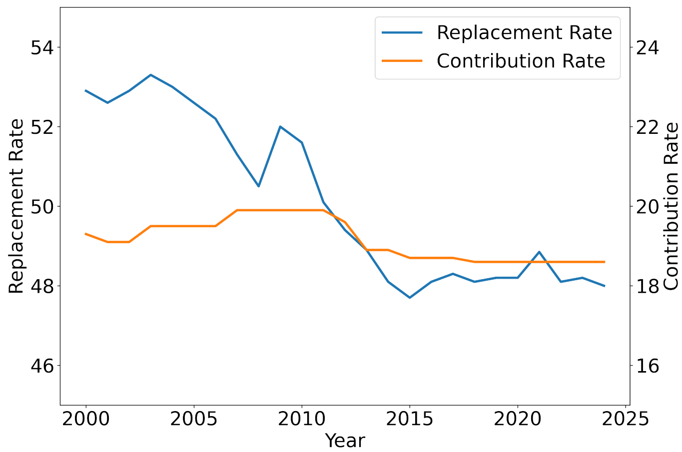


Notes: Comparison of articles covering pension deduction or retirement ages. The figure includes all articles that appear in major German news outlets. Information retrieved via The GDELT Project (2025).

B. Appendix to Data and Institutional Background

B.1. Pension Rates

Figure 11: Replacement Rate and Contribution Rate



Notes: Contribution rates are a percent of gross wages, half of which is owed respectively by employer and employee. The replacement rate is defined as the ratio GI/GP, where GI is the gross pension which a worker after 45 years of working at the average wage would get and GP is the average gross income of all insured workers.

Source: German Pension Insurance (DRV)

C. Appendix to Policy Beliefs

C.1. Questions

Current Early Retirement Penalty (ERP)

> *What percentage do you think the pension insurance company deducts from one's monthly pension if a person retires one year before their regular retirement age?*
>
> *(Answer: X percent)*

Robustness Questions:

> *How likely do you think it is that the pension insurance will deduct [1.5*X] percent or more from your monthly pension if you retire one year early?*
>
> *How likely do you think it is that the pension insurance will deduct [0.5*X] percent or more from your monthly pension if you retire one year early?*

Original (DE): Was glauben Sie wie viel Prozent die Rentenversicherung von der monatlichen Rente abzieht, wenn man ein Jahr vor dem gesetzlichen Renteneintrittsalter in Rente geht?

Expected Statutory Retirement Age (SRA)

> *Under the current system, the retirement age is increased to 67. How likely do you think the following three statutory retirement ages will be at the time of your retirement? Please answer so that your three statements add up to 100%.*
>
> *(The possible retirement ages are "67", "68", and "69 and above".)*

Original (DE): Im jetzigen System wird das Renteneintrittsalter auf 67 Jahre erhöht. Für wie wahrscheinlich halten Sie die folgenden drei Renteneintrittsalter zum Zeitpunkt Ihres Ruhestands?

Expected Claiming Age

> *At what age do you yourself expect to start receiving benefits from the statutory pension scheme (e.g. pension, retirement pension)?*
>
> *(Answer: X years)*

Robustness Questions:

> *How likely do you think it is that you will not start receiving benefits from the statutory pension scheme until age [X+1] or later?*
>
> *How likely do you think it is that you will start receiving benefits from the statutory pension scheme as early as age [X-1] or earlier?*

Original (DE): Ab welchem Alter erwarten Sie selbst, erstmals Leistungen aus der gesetzlichen Altersvorsorge (z.B. Rente, Pension) zu beziehen?

D. Appendix to Model

D.1. Variable Overview

Table 11: Variable Overview

Variable Name	Symbol	Possible Values
Decisions		
Labor Supply	d_t	$\{0 : \text{Retired}, 1 : \text{Unemployed},$
		$2 : \text{Part-Time}, 3 : \text{Full-time}\}$
Consumption	c_t	$[0, a_t]$
Discrete states		
Age	t	$30, \ldots, 100$
Type	τ	4 Types as combination of
		Low/High Education and Men/Women
Job Offer	o_t	$\{0 : \text{No Offer},\ 1 : \text{Job offer}\}$
Partner State	p_t	$\{0 : \text{Single}, 1 : \text{Partner working age}$
		$2 : \text{Partner retired}\}$
Health State	h_t	$\{0 : \text{Good Health}, 1 : \text{Bad Health},$
		$2 : \text{Disabled}, 3 : \text{Dead}\}$
Statutory Retirement Age	SRA_t	$\{65,\ 65.25,\ 65.50,\ \ldots, 72\}$
Information State	i_t	$\{0 : \text{Uninformed},\ 1 : \text{Informed}\}$
Continuous states		
Assets	a_t	$\mathbb{R}_{\geq 0}$
Work Experience	e_t	Projection to interval $[0, 1]$
Taste Shock	$\epsilon_t(d_t)$	GEV i.i.d. taste shocks

Notes: Key derived variables include pension points $PP(x_t)$, credited periods $CP(x_t)$, consumption equivalence scale $n_t(x_t)$, number of children, hourly wage $w_t(x_t)$, partner income $y_t^p(x_t)$, total household income $Y_t(x_t, d_t)$, benefits $B(x_t, d_t)$, and taxes $T(x_t, d_t)$, all of which are deterministic functions of the state variables listed above..

D.2. Auxiliary Markov Processes

D.2.1. Partner Transitions

The partner state p_t evolves stochastically with transition probabilities that depend on sex, education, age, and current partner state, none of which the agent can control. We impose certain restrictions on the process, which are informed by data and, in turn, inform our estimation strategy. The assumptions are: Agents can not transition from single to a retired partner. We observe almost none of these transitions in the data. The probability of becoming single when having a partner is independent of whether the partner is of working age or retired; i.e., the transition probability to the single state is the same for both partnered states. There is no transition from retired partner back to working age, only to being single, i.e., retirement is absorbing for the partner. All partners are retired at age 75, singles remain single, and partnered agents remain partnered from that age. In the data, most transitions at that age are due to the death of the partner, and we use this assumption to proxy widow pensions.

Formally, the transition of the partner state is given by:

$$\pi(p_{t+1}|x_t) = \Lambda_p\bigg(Z_p(x_t)'\,\phi_p)\bigg) \tag{37}$$

where Λ_p is the three-dimensional multinominal logistic distribution function. It provides transition probabilities for the state's single, working-age partner, and retired partner. The characteristics in $Z_p(x_t)$ are the sex, education, age, and current partner states. However, we estimate the partner transitions for the four types separately.

The assumptions outlined above allow us to follow a two-step estimation strategy. Ignoring the working-age and retired separation for partners, we estimate marriage and separation probabilities over the life cycle. This first step is similar to that of other papers using exogenous partner transitions (Adda et al., 2017; Blundell et al., 2016a). We do so by estimating a one-dimensional logistic regression for the probability of marrying and the probability of staying married. Second, we estimate the transition of the partner into retirement, including an intercept dependent on SRA, i.e., the probability of the partner to retire shifts with an SRA reform.

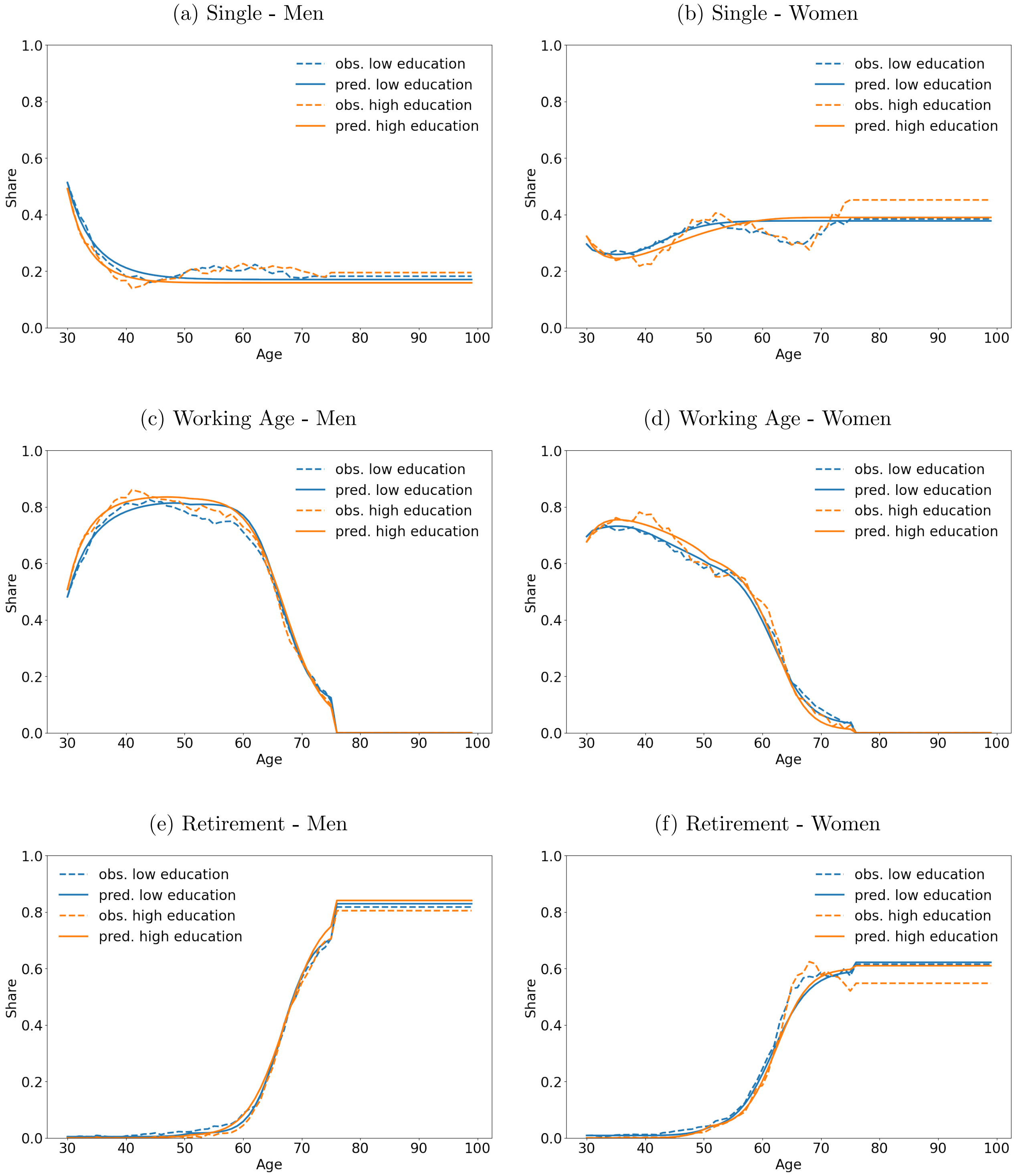
We use SOEP-Core data to estimate partner transitions. As the SOEP is a household panel, all members, including the partners, are also interviewed. We can classify them directly into retirement and working age. Table (12) reports our estimates for the three transitions outlined. We then use the estimated transition probabilities to simulate shares in each state for the four types across the life cycle, starting from the initial shares in the sample. Figure (12) illustrates these predictions and shows that we fit the empirical shares well.

Table 12: Partner Transition

Parameter	Men: Low Education	Men: High Education	Women: Low Education	Women: High Education
Single to Working Age				
Constant	0.017	0.032	0.089	0.030
	(7248.070)	(1457.579)	(1667.199)	(1038.093)
Age	0.001	0.049	0.231	0.062
	(405.859)	(61.315)	(95.554)	(79.629)
Age Squared	-0.205	-0.340	-0.691	-0.341
	(582.192)	(84.391)	(178.816)	(259.434)
Age Cubed	-0.013	-0.020	-0.036	-0.018
	(1895.319)	(684.668)	(598.321)	(2586.159)
Working Age to Working Age				
Constant	0.013	0.019	0.029	0.028
	(2069.870)	(1836.245)	(2466.642)	(1414.811)
Age	0.223	0.273	-0.057	0.098
	(249.825)	(279.150)	(151.012)	(82.257)
Age Squared	-0.066	-0.118	0.300	-0.023
	(1145.707)	(425.701)	(238.878)	(125.139)
Age Cubed	-0.011	-0.017	0.060	0.016
	(14545.708)	(1686.858)	(580.233)	(641.351)
Working Age to Retirement				
Constant	-12.121	-7.374	-9.944	-11.144
	(14031.539)	(10917.219)	(10409.389)	(7158.548)
Age	-0.607	-0.381	-0.670	-0.467
	(653.760)	(551.633)	(512.637)	(384.676)
Age Squared	3.273	2.089	2.798	2.450
	(976.169)	(914.485)	(840.614)	(687.827)
Age Cubed	-28.030	-16.586	-20.770	-21.012
	(4587.847)	(4992.267)	(4615.105)	(4096.085)
SRA Age Difference	-0.216	-0.070	-0.048	-0.106
	(15.923)	(9.457)	(9.181)	(8.534)

Notes: Standard errors in parentheses. Estimates for logit transitions between the states. States are absorbing from the age of 75 onwards.

Figure 12: Shares in Partner States



Notes: Simulated shares of individuals in each partner state from estimated transition probabilities. *Data:* SOEP-Core

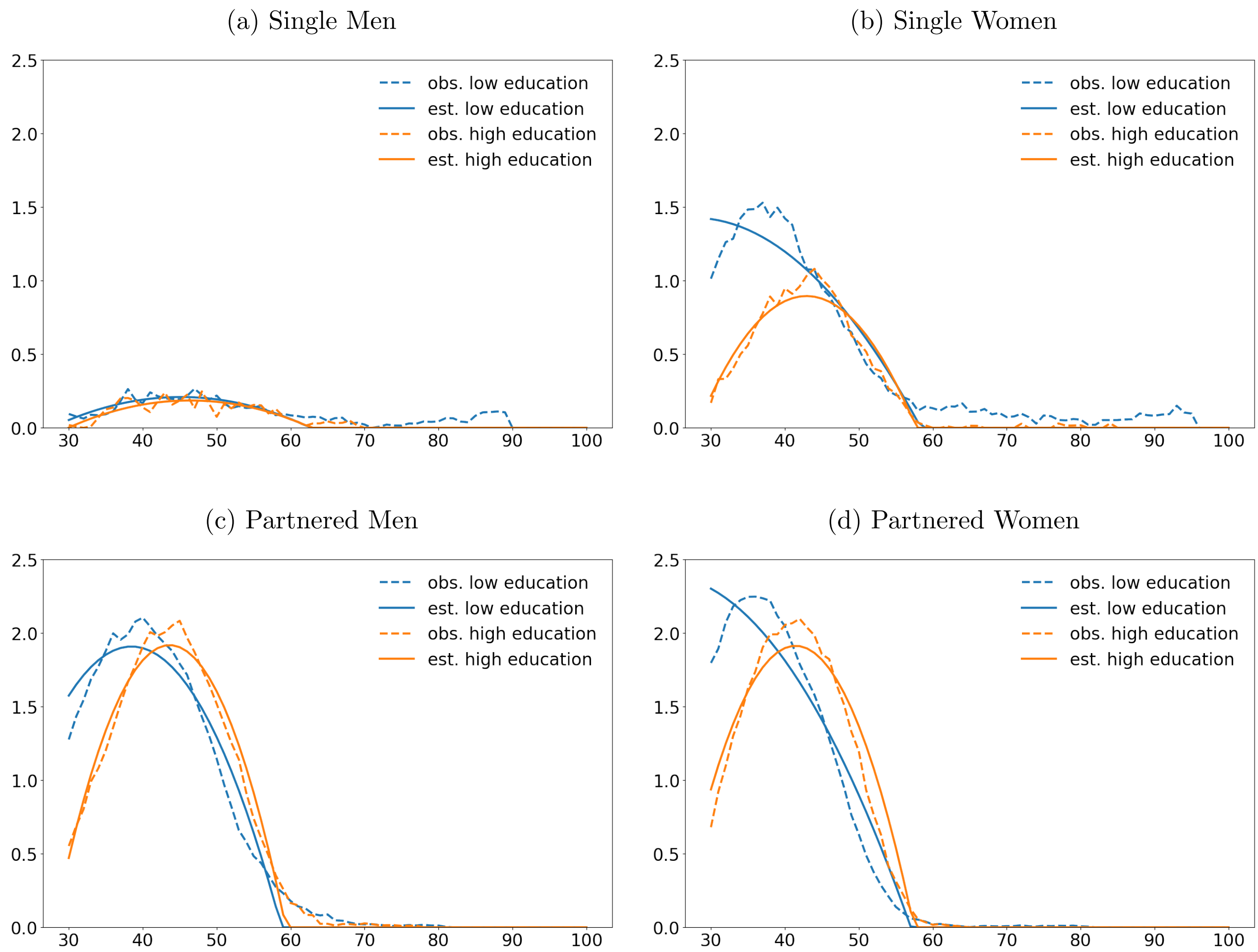
The partner state, together with type (sex, education) and age, determine the number of children in the household. We use the number of children to construct the consumption equivalence scale and, if working, for additional disutility. We approximate the number of children by OLS. We provide the OLS estimates and fits below:

Table 13: OLS Parameters Children

Men				
	Low Education		High Education	
Parameter	No Partner	Has Partner	No Partner	Has Partner
Constant	0.053	1.575	0.002	0.471
	(0.013)	(0.023)	(0.020)	(0.035)
Period	0.021	0.079	0.022	0.212
	(0.002)	(0.003)	(0.003)	(0.005)
Period Squared	-0.001	-0.005	-0.001	-0.008
	(0.000)	(0.000)	(0.000)	(0.000)
Women				
	Low Education		High Education	
Parameter	No Partner	Has Partner	No Partner	Has Partner
Constant	1.419	2.302	0.217	0.937
	(0.028)	(0.019)	(0.035)	(0.029)
Period	-0.007	-0.028	0.105	0.171
	(0.004)	(0.003)	(0.005)	(0.004)
Period Squared	-0.002	-0.002	-0.004	-0.007
	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Standard errors in parentheses. Estimates from OLS regression.

Figure 13: Number of Children



Notes: OLS estimation of number of children in the household conditional on type and partner state over the life-cycle.

D.2.2. Job-offers and Destructions

The job offer state governs the agent's ability to choose employment; the agent can choose part- or full-time if the job offer state o_t equals 1. If her job-offer state equals 0 and she does not have the possibility to choose retirement, she is forced to be unemployed this period. We incorporate two independent processes with the job-offer state. Namely, job destruction for those previously employed or job offers for those previously unemployed.

The Markov transition matrix of o_t consists of two independent probability distributions, which we estimate separately. We outline in Section 5 why the job offer process cannot be estimated outside the model and provide the empirical specification as well as the estimation strategy for this process. Job destruction probabilities, however, can be directly identified from the SOEP using unemployed individuals previously employed. We utilize the SOEP's question on the reason for job departure and classify individuals in job offer state 0, who did not voluntarily leave their jobs.

If the agent chooses employment in the current period, her job could be destroyed, and she would have the job offer state $o_{t+1} = 0$ in the next period. In this case, the transition probability for the job offer state is given by:

$$\pi(o_{t+1} = 0 | x_t, d_t \in \{2, 3\}) = \Lambda_{sep}\left(Z'_{sep}\phi_{sep}\right) \tag{38}$$

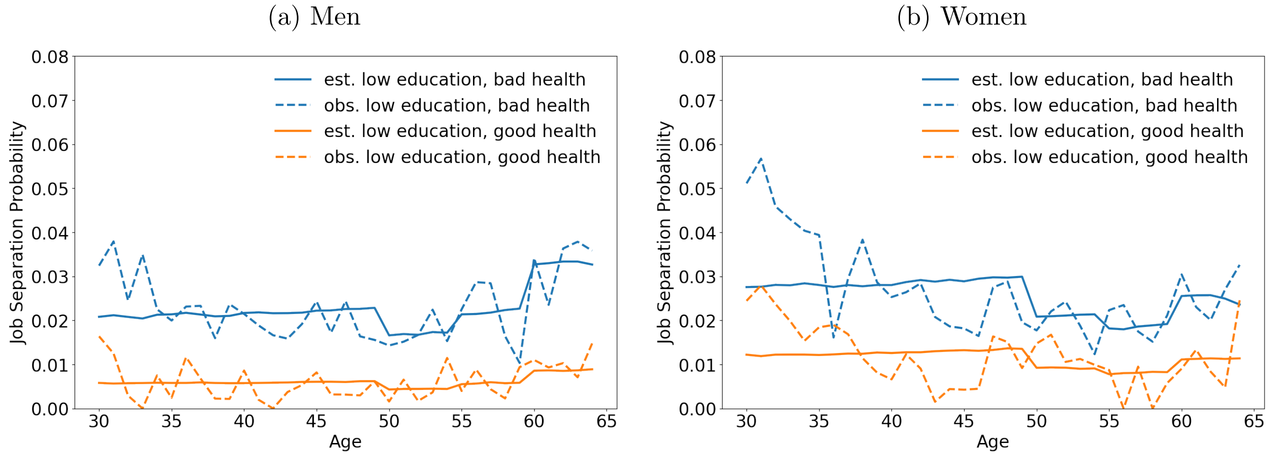
where Λ_{sep} is the logistic distribution function, which predicts a job separation, conditional on education, age, and a constant. We separately estimate the probability of job separation for men and women. We estimate the probability from SOEP-Core data, where individuals are asked why they left their jobs. We only consider involuntary job loss as job separation. We restrict our sample to the start age of our model and 65 to have enough observational power. We assume that job separation rates remain constant after 65 to the age of forced retirement (72). The fit and estimates of our estimated probability are documented below:

Table 14: Job Separation Parameters

Parameter	Men	Women
Constant	-3.006	-2.727
	(0.085)	(0.072)
High Education	-1.266	-0.791
	(0.109)	(0.079)
Good Health	-0.933	-0.952
	(0.086)	(0.074)
Age $\geq$ 50	-0.344	-0.403
	(0.111)	(0.095)
Age $\geq$ 55	0.224	-0.165
	(0.142)	(0.135)
Age $\geq$ 60	0.368	0.295
	(0.143)	(0.153)

Notes: Standard errors in parentheses. Estimates from a logit regression on job separation, using the *plb0304_h* job separation variable from the *pl* sample in the SOEP.

Figure 14: Job Separation Probabilities



Notes: Estimated job separation probabilities using logistic regression. Data is weighted.

The second process incorporated in the job offer state is the job offer process for unemployed agents. If the agent chooses unemployment during this period, it predicts the probability of being able to choose employment in the next period ($o_{t+1} = 1$). Why and how we estimate this process via maximum likelihood can be found in Section (5.1).

D.2.3. Health and Death

Our health process h_t tracks four different states: Good Health, Bad Health, Disability Pension Eligible, and Death. Survival probabilities are type-specific and depend on health and age. This is the reason we use a joint Markov process h_t to model the stochastic transitions of health and survival jointly. We document the estimation of survival at the end of this section.

We treat disability pension eligibility as a substate of bad health. If the agent is in bad health in a period, there is a conditional probability of being eligible for disability pension. As we can not observe disability pension eligibility, we estimate the conditional probability of being in that state jointly via maximum likelihood. Section (5) outlines the estimation strategy. Additionally, we assume that he agent has the same probability of transitioning to good health or death as if he were in bad health.

We use the SOEP-Core question on self-reported health to classify individuals into good and bad health and estimate the probabilities to transition between the two, following closely Haan and Prowse (2014). Specifically, we use a logistic regression to estimate the probability of being in bad health in the next period. We use the following empirical specification:

$$\pi(h_{t+1}|x_t) = \Lambda_h\Big(Z_h'\phi_h\Big) \tag{39}$$

where Z_h includes current health state and age. Table (15) documents the estimated parameters for each type. We use the estimated parameters to predict transition rates and simulate with them from the initial share of healthy individuals. Figure (15) shows the fit against observed shares in the data. We fit the decline in the share of healthy individuals well.

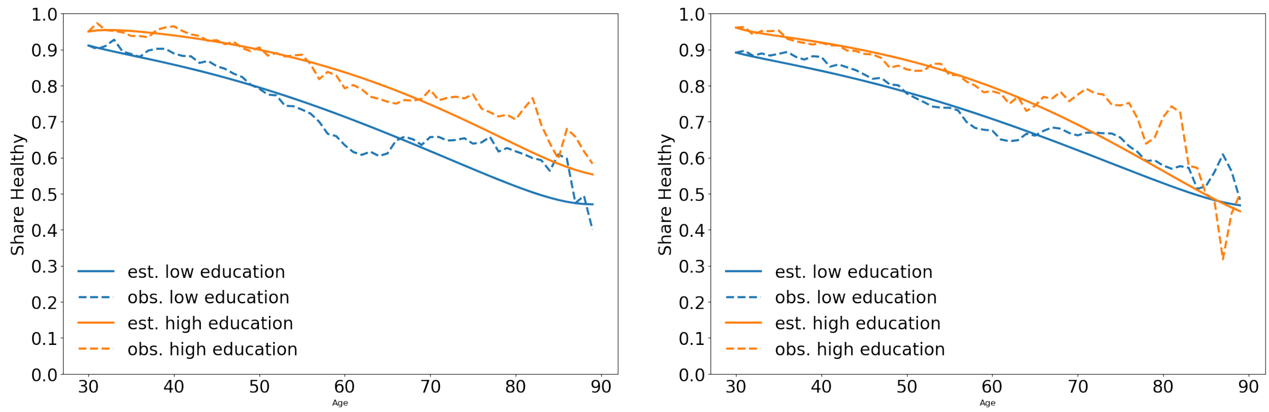
Table 15: Health Parameters

	Low Education		High Education	
	Good Health	Bad Health	Good Health	Bad Health
Men				
Constant	-4.277	0.365	-5.120	-0.534
	(0.084)	(0.110)	(0.150)	(0.194)
Age	0.027	0.026	0.032	0.038
	(0.001)	(0.002)	(0.003)	(0.003)
Women				
Constant	-3.910	0.319	-4.581	-0.764
	(0.068)	(0.086)	(0.132)	(0.173)
Age	0.023	0.024	0.027	0.042
	(0.001)	(0.001)	(0.003)	(0.003)

Notes: Standard errors in parentheses. Estimates from a logit estimation for the probability of being in the bad health state, conditional on type and current state.

Figure 15: Share of People in Good Health

(a) Men (b) Women



Notes: Predicted of healthy people in comparison to data.

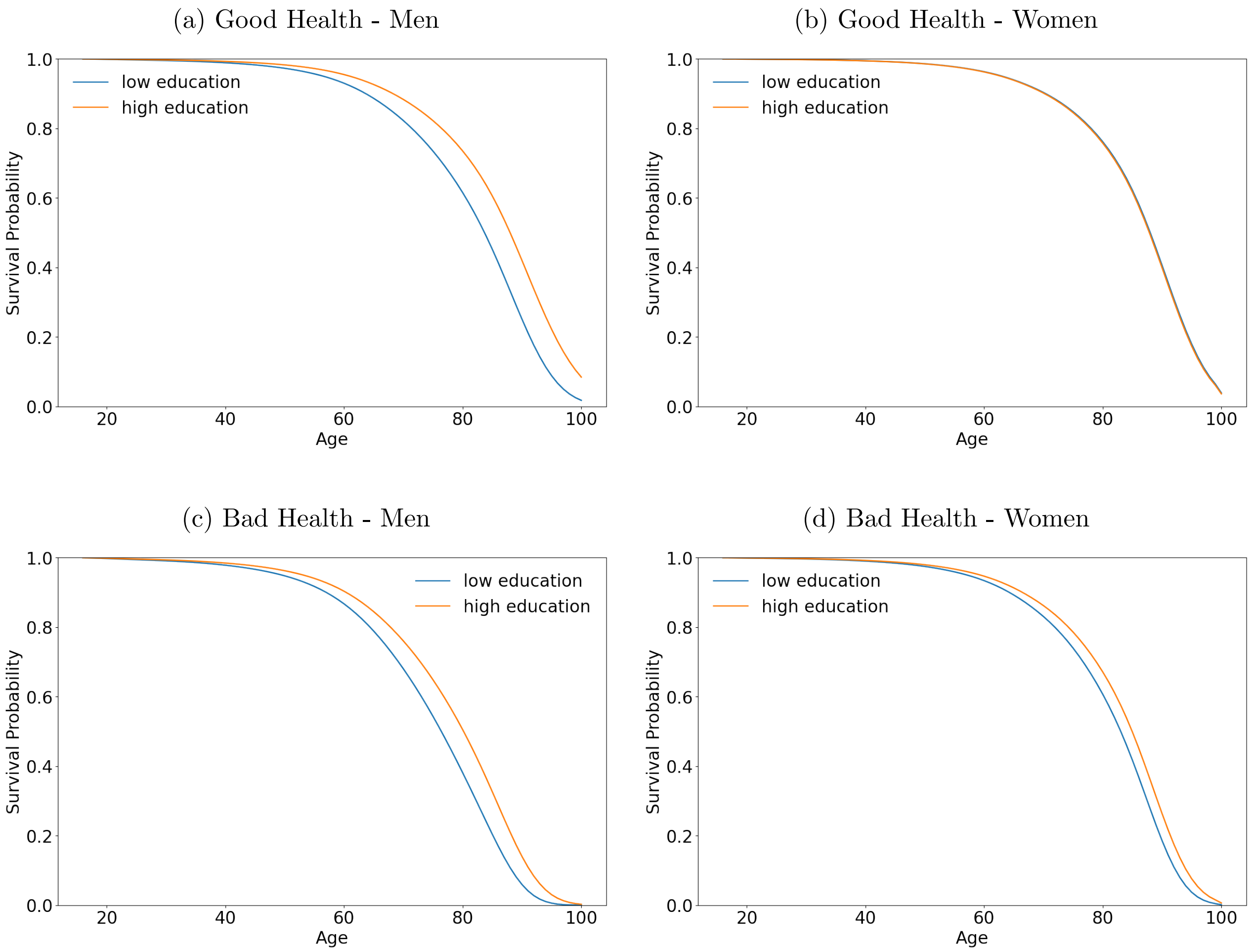
We also track death via our health process h_t. In the case of death, the agent bequeathed all its wealth and received a bequest utility. The probability of dying depends on health. Therefore, we use a joint Markov process together with health. To estimate survival probabilities, we can not only rely on the SOEP. Instead, we follow Lampert et al. (2019) and use a two-step procedure: First, we generate group-specific hazard ratios with the SOEP. Second, we use the Lifetables from the German statistical office to correct and match the German mean death probability. The procedure relies on the assumption of randomness (independent of the groups we consider) that death is observed in the SOEP data. Below are the estimated hazard functions and hazard ratios:

Table 16: Hazard Ratios

	Low Education		High Education	
	Good Health	Bad Health	Good Health	Bad Health
Men				
Hazard Ratio	0.717 (0.028)	0.454 (0.033)	1.408 (0.043)	1.002 (0.063)
Women				
Hazard Ratio	0.696 (0.029)	0.709 (0.069)	1.268 (0.040)	1.014 (0.092)

Notes: Standard errors in the parentheses are calculated using the Delta Method. Hazard ratios are the multipliers of the sex-specific age profiles of the survival probability. Values above 1 indicate a higher than average survival probability.

Figure 16: Share of People Alive



Notes: Estimated survival functions. We use SOEP-Core to create adjustment factors and Lifetables from Destatis to match average survival.

D.3. Modelling and Estimation of Income

D.3.1. Pension calculation

The formula for calculating pension claims in Germany consists of three parts. First is the pension point value, which we use as the population-weighted average from the 2010 pension point values for East and West Germany. Second, the pension points themself accumulated over the working life, and third, the deduction factor if the individual retired early. The second and third factors we track through the experience stock, which we will outline in this section.

Each individual receives pension points in the ratio of their yearly income compared to the overall mean wage of all working individuals. Let w_m be the mean wage, and h_t be the agent's work hours(either part-time or full-time). The average (averaging over income shocks) yearly income for any experience level e_t is given by

$$w_t * h_t$$

Therefore, the pension points at any age t, working h_t hours are:

$$\frac{w_t * h_t}{w_m}$$

If an agent retires at age t, she has a certain number of years of experience e_t. This corresponds to working full-time hours for e_t years. Let $h_{f,\tau}$ be the type specific full-time hours and define $w_{m,\tau} = w_m / h_{f,\tau}$. We approximate the number of pension points by assuming the agent has worked e years full-time. To account for the age trend in wages, we use the mean experience per type at age 30 and assume he has worked e years full-time thereafter.

With the closed-form solution for the pension points, we can calculate the monthly pension by:

$$y_t(x_t, 0) = PP(x_t) * PPV \tag{40}$$

The factor PPV is the pension point value, for which we use the 2020 east-west weighted average. Note that the function above is invertible. Assume that an agent retires one year early. Her pension would be given by:

$$y_t(x_t, 0) = PP(x_t) * PPV * (1 - 0.036) \tag{41}$$

Given the type of the agent, we can map the new pension back to the experience stock, such that the reduced pension corresponds to an unreduced pension with a new experience stock e'_t. With this method, we can track pension deductions for the experience stock without tracking the retirement age.

D.4. Wage Process

In the model, we assume that individuals can invest in their human capital by working full-time or part-time. We estimate their returns to experience using two-way fixed-effects regressions on SOEP core panel data. The estimation sample is the same as the one used for the model estimation, i.e., men and women over 30 who work full- or part-time throughout the estimation period 2010-2017. Since time-fixed effects absorb the effects of aggregate income growth and inflation, all monetary quantities in the model are expressed in 2010 Euros. The returns to experience are identified as individual variations in wages over time. We estimate the following equation for each sex and education type using observations of wages and experience for each individual i and time t:

$$\ln(w_{it}) = \gamma_{0,\tau} + \gamma_{1,\tau} * \ln(exp_{it} + 1) + \gamma_{2,\tau}\, t\, \mathbb{1}\{t > 50\} + \xi_i + \mu_t + \zeta_{it}. \tag{42}$$

Our estimates of $\gamma_{0,\tau}, \gamma_{1,\tau}$, directly correspond to the parameters in equation (8). We cluster standard errors across individuals and time and estimate the wage process's variance σ_w^2. We document our estimates as well as the below.

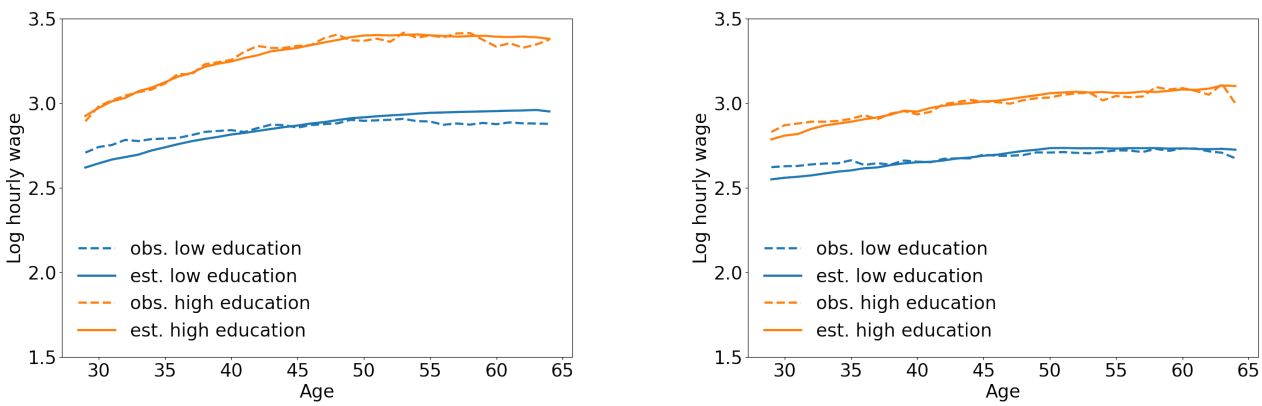
Table 17: Wage Parameters

Parameter	Low Education Men	Low Education Women	High Education Men	High Education Women
Constant	2.292	2.398	2.571	2.563
	(0.153)	(0.081)	(0.101)	(0.087)
Return to Experience	0.214	0.147	0.287	0.210
	(0.045)	(0.028)	(0.033)	(0.031)
Age Trend above 50	-0.002	-0.007	-0.013	-0.008
	(0.002)	(0.002)	(0.003)	(0.003)
Income Shock Std.	0.120	0.131	0.123	0.133
	(0.000)	(0.000)	(0.000)	(0.000)

Notes: Standard errors in parentheses. Estimates from panel regression with individual and year fixed effects. We employ a Heckman Correction control function approach to account for selection bias (Heckman, 1979). Standard errors clustered at the individual and year level.

Figure 17: Wage fit

(a) Men (b) Women



D.4.1. Partner Income Process

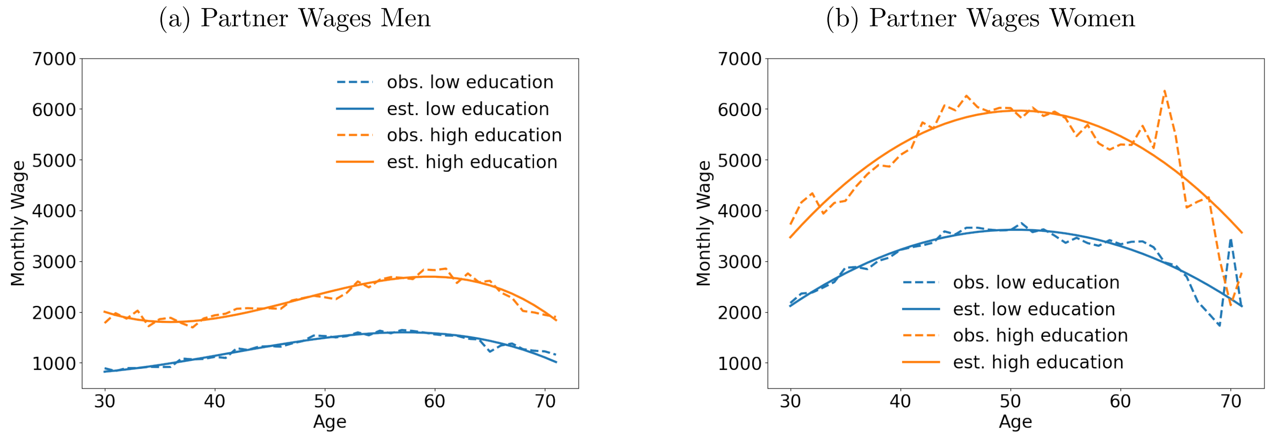
We approximate the partner's income through the state variables of the agent himself. First, consider the partner state: If the agent is single, there is no partner income. When having a partner in working-age life, we approximate the partner's wage by OLS of wages onto the agent's age and age squared. We assign unemployed partners a wage of zero. Therefore, the partner income is a combination of the wages of partners and those of unemployed partners. We do the approximation for education and sex separately. We use the old-age incomes of the retired partner and their mean as a fixed partner income. Below, we show the fit of the OLS approximation in working life as well as the parameters:

Table 18: Partner Wage Parameters

	Low Education		High Education	
Parameter	Men	Women	Men	Women
Constant	823.592	2118.940	2004.556	3471.683
	(32.948)	(46.744)	(80.210)	(119.995)
Period	19.237	146.642	-72.619	241.121
	(6.965)	(6.168)	(16.676)	(16.334)
Period Squared	1.713	-3.579	7.315	-5.825
	(0.412)	(0.173)	(0.980)	(0.481)
Period Cubed	-0.050	—	-0.138	—
	(0.007)		(0.017)	

Notes: Standard errors in parentheses. Estimates from panel regression with individual and year fixed effects. OLS regression on the agent's state.

Figure 18: Partner Wages of Working Partners



Having a wage prediction over the life-cycle, we use these to approximate the partner's pension, which remains constant over retirement.

E. Appendix to Results

E.1. Welfare Measure

For the welfare analysis, we follow Low et al. (2010) who measure the welfare effects by the consumption variation that is welfare equivalent to the change from one scenario to the other. Formally, let A denote the counterfactual environment and let B denote the baseline scenario.

The welfare value of scenario A is denoted by γ_A and solves $V_B(\gamma_A) = V_A(0)$, where

$$V_e(\gamma) = \mathbb{E}\left[\sum_{t=30}^{T} \beta^t u(c_t(1+\gamma), d_t, \theta, X_t)\right], \text{ for } e \in \{A, B\}. \tag{43}$$

Thus, γ_A describes the relative increase in per-period consumption to equal the average discounted utility in the counterfactual scenario [44]. Consequently, a positive value is associated with a welfare gain in the counterfactual and a negative vice versa.

[44] In this calculation, the consumption adjustment γ_A is implemented ex-post and, therefore, does not affect behavior.