Where's my pension gone? Labour supply effects of mistakes in retirement planning

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Abstract

I analyse how agents respond to realising mistakes in their retirement planning using a reform to the state pension age for women in the UK. This reform raised the age at which women could start receiving their public pension by several years. However, many women were not aware that this reform had been put in place, leading them to have mistaken beliefs about when they would be able to start receiving their pension. I first document the correlates of mistaken beliefs using data from the English Longitudinal Study of Ageing (ELSA) and present descriptive evidence suggesting an increase in labour supply after people realise they were mistaken about their pensions. I then build a life-cycle model of consumption and labour supply around retirement, where agents face a cost of cognitive effort of paying attention to reforms to the pension system, and I estimate the model by matching data moments from ELSA for the cohorts of affected women. I find that mistaken beliefs about the reform cost agents £1148 on average, with notable heterogeneity by demographics, and that agents in the model significantly increase labour supply once they realise their mistakes.

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1 Introduction

A longstanding concern for policymakers and researchers is whether people are saving adequately for retirement (Banks, Emmerson, et al. 2005; Crawford and O'Dea 2020; Scholz, Seshadri, and Khitatrakun 2006). In particular, over-optimism about medical costs (Department of Health 2011), income in retirement (Hentall-MacCuish 2025) or underestimating longevity (O'Dea and Sturrock 2018) could lead to people having inadequate resources and hence a lower quality of life in retirement. Governments around the world have taken action to overcome these behavioural biases such as auto-enrollment in private pension schemes (OECD 2019).

The existing literature has taken several approaches to assessing whether people are saving adequately for retirement. Some authors have tried to assess whether consumption drops around retirement are evidence of drops in welfare from bad planning (Battistin et al. 2009; Olafsson and Pagel 2018). Others have taken a more structural approach, building models of agents' decision-making around retirement and assessing the extent to which heterogeneity in preferences (Crawford and O'Dea 2020) or beliefs (O'Dea and Sturrock 2020) can explain behaviour which appears to be evidence of bad planning.

A key difficulty with analysing the issue of optimal saving for retirement is that it is rare that we are able to identify who is planning badly for retirement. In principle, someone might have low savings in their late working career because of previous negative shocks they have suffered, or because they discount the future very strongly, or because they have resources which are not observed by the econometrician. In all these cases it is difficult to argue that these people are making mistakes, or are planning badly. To understand whether people are making mistakes, we need to have some information on the beliefs they have about the future: if they have drastically incorrect beliefs about how much income they will have in future, or how likely they are to face crippling medical costs, then we can be much more confident in saying that they are making mistakes. Moreover, to understand the extent to which these planning mistakes are detrimental to welfare, we must be able to observe how agents change their behaviour - and the costs they incur from doing so - when they realise their mistakes. For instance, if people had highly inaccurate beliefs about their future pension income, but their behaviour would be similar whether or not their beliefs were accurate, then their planning mistakes may not be very costly.

This paper tackles this difficulty by using household survey data on subjective beliefs about future pension income eligibility, where these beliefs can be easily verified as being correct or not. This allows me to identify i) who is making mistakes, ii) exactly how the agents are overestimating their income in retirement and iii) how agents respond after they realise their mistakes. As such, the contribution of this paper is to use a new source of data to gain a cleaner and more direct insight into the prevalence, drivers and consequences of inadequate planning for retirement.

More specifically, this paper examines these issues by exploiting a reform to the state pension age (SPA) - the earliest age at which people can claim a public pension - for women in the UK. For certain cohorts of women, their SPA increased by several years, from 60 to (for the most affected women) 65. Given that in my data state pension income makes up around 64% of the median single retiree household's income and around 47% of the median couple retiree household's income, this amounted to a very substantial change in income for women looking ahead to their early 60s.

The key feature of the reform, for the purposes of this paper, was that many women were unaware of how the reform affected them, even when close to retirement (Holman, Foster, and Hess 2020). As such, many will have had a "moment of realisation" shortly before their original planned retirement date when they realise that a future source of income they were banking on will instead be delayed by several years. Using high-quality panel data from the English Longitudinal Study of Ageing I am able to track the scale and nature of these mistakes, and how agents responded once they realised their mistakes.

An important advantage of this setting for analysing the (in)adequacy of agents' planning for retirement is the simplicity of the object - the SPA - that agents have beliefs over. For instance, if we observe an agent with incorrect beliefs about their SPA, we can assess by how much they are overestimating their income in retirement, and once they realise their mistake, this is plausibly a relatively clean shock to expected future income. In contrast, if someone suffers a health shock, then this reduces their expected future income, but the amount of the reduction is unclear and any behavioural responses to the change in their future income will be conditioned by their new health problem, rather than being just a response to changes in expected future income.

However, a complication is that the correctness of agent's beliefs about the SPA is endogenous. Agents for whom the "stakes" (Brown and Jeon 2024) of the issue of having correct pension beliefs are high - e.g. those whose optimal behaviour is highly sensitive to what their expected future income is - will plausibly be more likely to do their research to ensure that they know the truth of their SPA. Moreover, steps people might take to protect themselves against drops in future income, such as re-entering the labour market, are also plausibly steps that make it more likely for people to acquire information about the pension system. Thus, understanding how people respond to acquiring better information about the adequacy of their retirement plans - and thus understanding the extent to which people plan adequately for retirement - will require a model of endogenous information acquisition. To this end, I develop and estimate a rich quantitative life-cycle model of labour supply and consumption around retirement with rational inattention about the SPA and use this to assess agents' responses to learning about the adequacy of their retirement plans.

The paper proceeds as follows. First, I use ELSA data on women's beliefs about their

SPA to examine what are the correlates of mistaken beliefs in the data. I find that homeowners, those in the labour force, those with private pensions and those who have a long financial planning horizon are more likely to have correct beliefs, though strikingly there is no significant relationship between correct beliefs and education levels and women in couples are actually less likely to have correct beliefs. This is consistent with the agents with higher education or in couples facing both lower costs of acquiring information - due to plausibly higher financial literacy and having an extra source of information in the household, respectively - and facing lower incentives to acquire information, because the state pension is a smaller fraction of their expected income in retirement. Moreover, I find some evidence that when agents transition from having incorrect beliefs to having correct beliefs in the data both their and their spouses' probability of working increases, as does their annual earnings, though there is no obvious corresponding change in consumption, asset holdings or measures of financial well-being. While the endogenous nature of information acquisition prevents a simple causal interpretation these findings are consistent with agents cushioning the blow of lower expected future income by working more rather than reducing their consumption or drawing down their assets.

Then, I develop the quantitative model which is the focus of the paper. Agents start the model at age 50. They are either attentive of their true SPA, or inattentive. For attentive agents, the model consists of a labour and consumption choice every period, where agents face different wages and costs of working according to their demographics and state variables. For inattentive agents, there is an additional choice every period of whether to "do their research" about the true SPA and become attentive, where the costs of becoming attentive also vary by demographics and state variables.

I estimate a large number of parameters within the model, allowing for significant heterogeneity in wages, costs of working and costs of becoming attentive. The model is estimated by the method of simulated moments, matching data moments on women and men's labour supply, labour earnings, correctness of beliefs and responses to realising mistakes. Notably, I estimate that agents face significant costs of re-entering the labour force in terms of wages and disutility of working, exacerbating the impact of inadequate planning for retirement, and that the costs of becoming attentive vary importantly in the population, with agents in couples, with college educations and attached to the labour force facing lower costs.

Using the estimated model I find that agents indeed increase their labour supply and work longer into their 60s once they realise that their SPA beliefs were in error. Moreover, I quantify the extent of losses because of inattentiveness to the reform: on average ex post, households who start the model with incorrect beliefs would be indifferent between a £1148 increase in wealth at the start of the model and living in a world where they had always had correct beliefs. By decomposing the costs of the imperfect communication of the reform I find that cohorts who faced smaller changes in their SPA, or who were further from retirement at the start of the model, faced less cost, as did those with more education who were protected against the consequences of mistakes. Finally, I show that interpreted as a purely cost-saving measure, the imperfect communication of the reform did little to impact its effectiveness.

This paper contributes to two different literatures. Most narrowly, it adds to work on the effects of changing statutory retirement or pension eligibility ages across several countries. This type of policy reform has been studied in the context of the UK (Cribb, Emmerson, and Tetlow 2016; Hentall-MacCuish 2025), US (Deshpande, Fadlon, and Gray 2024), Austria(Staubli and Zweimüller 2013), Denmark (García-Miralles and Leganza 2024a) and Japan (Nakazawa 2022), amongst others. The literature has generally found that people adjust their labour supply to work longer as the SPA moves back (García-Miralles and Leganza 2024b). The contribution of this paper relative to other work in this area is the exploiting of agents' beliefs and mistakes about their SPA, rather than just using the change in the statutory early retirement age. By doing so, I can use more variation in the timing and size of expected income shocks to assess the effects on labour supply, and I can capture the fact that ignorance of the nature of reforms can modify their welfare impact.

The paper is closest in topic and approach to contemporaneous work by Hentall-MacCuish (2025), who similarly studies UK women's SPA mistakes using a dynamic model of rational attention. He finds that costly attention and ignorance of the true SPA can explain an empirical puzzle where people are disproportionately more likely to retire at exactly their SPA even though the financial incentives to do so are apparently limited, building on previous work in this area by Cribb, Emmerson, and Tetlow (2016). While the current paper and Hentall-MacCuish (2025) share a policy context and broad empirical approach, there are important differences in model construction. Hentall-MacCuish (2025) develops a sophisticated model of dynamic rational inattention whereby agents continually update their beliefs about the SPA every period depending on previous information; this allows detailed consideration of the effects of rational inattention on labour supply but requires simplifications elsewhere in the model, such as imposing inelastic labour supply for spouses, estimating wage processes outside of the model and cutting back on state variables that could determine incentives to work, such as previous labour supply. In contrast, the current paper offers a much simpler model of rational inattention, where agents are always attentive or inattentive. This implies a less detailed treatment of the drivers of incorrect beliefs but allows more complexity in parts of the model that are relevant to assessing the welfare effects of mistakes in SPA beliefs. For instance, in the current paper, both women and men in the household make labour supply decisions and there is much more heterogeneity in wages, disutility of working and costs of paying attention by a broad set of exogenous and endogenous state variables. As such, this paper is able to contribute a detailed assessment of the welfare effects of mistakes in retirement planning.

A second, broader, literature to which this paper contributes is the large literature featuring life-cycle models of labour supply and consumption around retirement, particularly those concerning the adequacy of preparations for retirement. The literature on labour supply around retirement is surveyed in Blundell, French, and Tetlow (2016). More general life-cycle papers on behaviour around and into retirement focussed on precautionary saving (De Nardi, French, and John Bailey Jones 2016), medical costs (De Nardi, French, and John B. Jones 2010) and bequest motives (Lockwood 2018), while other authors have assessed the importance of heterogeneity in preferences (Crawford and O'Dea 2020) or beliefs (O'Dea and Sturrock 2020). The current paper's focus on quantifiable and observable mistakes in beliefs about future income allows me to contribute an analysis of how people tend to respond to realising their mistakes in retirement planning and what determines the welfare costs they suffer when doing so.

The rest of the paper proceeds as follows: in Section 2, I establish some basic empirical facts about the pension reform and mistaken beliefs. In Section 3, I present the quantitative model. Section 4 discusses estimation, identification and model fit, while Section 5 contains welfare analysis and counterfactuals. Section 6 concludes.

2 Empirical facts

2.1 Policy context

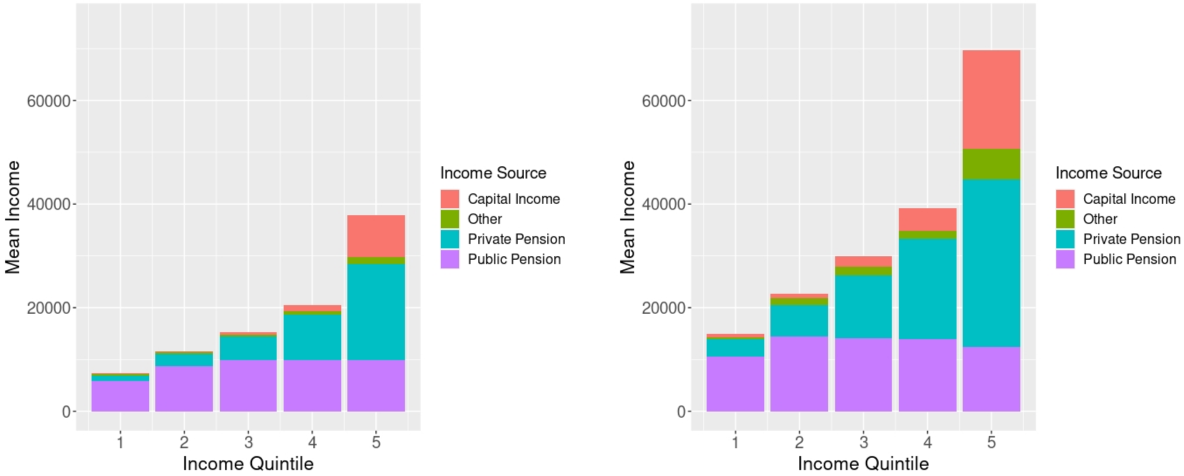
The UK state pension is a regular payment from the government that can be claimed from an individual's State Pension Age (SPA) onwards. The amount received depends on the years of National Insurance (NI) contributions that an individual has made, with those making the maximum amount of NI contributions receiving a "full" state pension. There is also a small earnings-based component which applied differently for different cohorts though as Figure 1 below suggests in practical terms the absolute amount received did not vary much along the income distribution. In 2025-26, the "full" state pension is £230.35 per week, or approximately £12k per year (Department for Work and Pensions 2025a). In Appendix A I discuss in more detail the exact structure of the state pension.

The state pension is an important source of income for retired households. Figure 1 below shows a breakdown of income by source across the income distribution for retiree households in 2018, the most recent wave of ELSA data that I use. In the middle quintile of single households, 64% of their income comes from public pensions[1], whereas for couple households, this figure is 47%. There is little variation in the absolute amount of the state

[1]In the figure, "public pensions" groups together the state pension and other associated public pensions such as widow's pension and disability pensions. On average, the state pension's share of total public pension income in the data is 95%.

pension across the income distribution, with instead increases in private pension being notable for richer households relative to poorer households.

Figure 1: Income distribution by quintile - retirees



(a) Singles (b) Couples

Notes - single households where the household member self-describes as retired, and couple households where both household members self-describe as retired. Means are weighted by ELSA person-level cross-sectional weights.

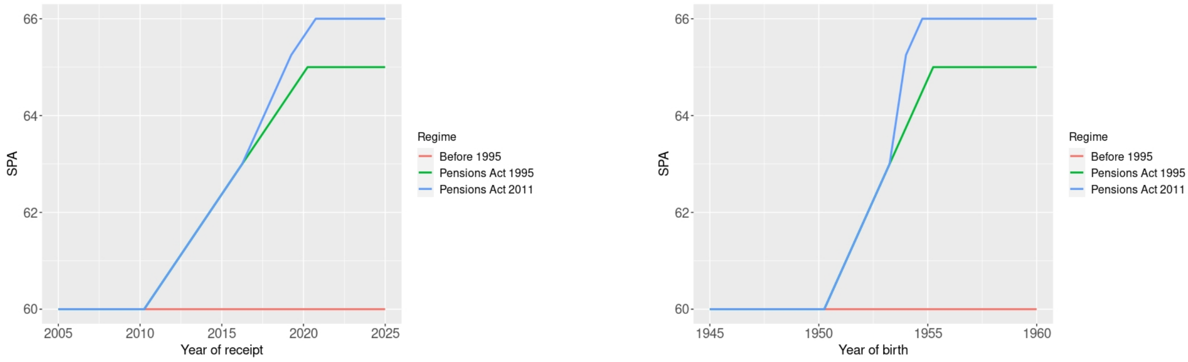
2.1.1 Reform to women's SPA

From the 1940s to 1995, the SPA had been 65 for men and 60 for women (Mackley, Thurley, and McInnes 2021). In 1995, the Pensions Act was passed, decreeing that the women's SPA would rise from 60 to 65 gradually between 2010 and 2020. Thus, women born after 1950 - who were 45 or younger at the time of the reform - would receive their state pensions later than the age of 60. In 2011, a new Pensions Act was passed, accelerating the rise in the SPA. Figure 2 below shows SPA for women, before the 1995 Pension Act, under the 1995 Pension Act and under the 2011 Pensions Act.

The left hand graph shows the prevailing SPA for women in a particular calendar year, under the pre-1995 regime, the 1995 Pensions Act and the 2011 Pensions Act. The 1995 Pensions Act only affected SPAs from 2010 onwards, i.e. 15 years after the passage of the Act, and set out a plan for the SPA for women to 65, i.e. equality with men, by 2020. The 2011 Pensions Act accelerated the increase to 65 between April 2016 and November 2018, and then added an extra increase up to 66 (for men and women) between November 2018 and October 2020.

The right hand graph shows the SPA for different women by year of birth instead. Only those born after 1950 were affected, with more significant changes for younger cohorts. The 2011 Pensions Act brought particularly large changes for those born in 1953 or later, who would have been 58 or younger at the time of the reform.

Figure 2: SPA for women by year of receipt and by year of birth



(a) By year of first receipt

(b) By year of birth

Notes - Data from Department for Work and Pensions (2014).

As Mackley, Thurley, and McInnes (2021) describe, a key aspect of the reform was that there was widespread ignorance about the consequences among affected groups. The Parliamentary and Health Service Ombudsman (PHSO) found in 2020 that maladministration had taken place in the communication of the reform to women whose SPA was increasing. Department of Work and Pensions research indicated as early as 2004 that there was widespread misunderstanding of the reform, and the Department proposed in November 2006 that it write directly to affected women to inform them of the changes, but the PHSO found that the letters were not sent until March 2009 (PHSO 2021). The PHSO then subsequently found in 2024 this maladministration had led to injustice and proposed that the government pay out in compensation to affected women (PHSO 2024), a proposal that has been rejected at the time of writing (Department for Work and Pensions 2024). It is this miscommunication and misunderstanding of the reform that allow me to assess the labour supply and welfare consequences of mistakes in retirement planning.

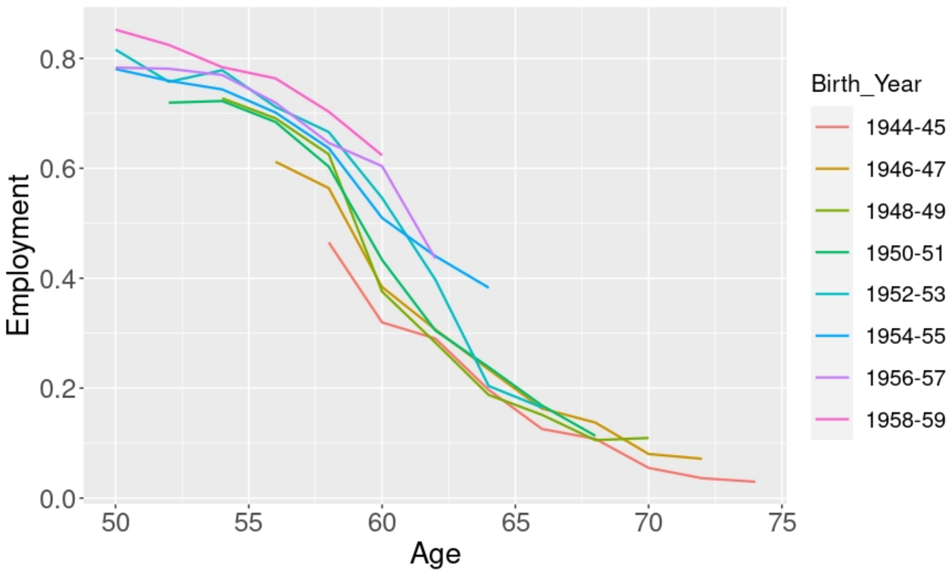
2.2 Descriptive evidence

2.2.1 Labour supply by cohort

To establish some descriptive facts, I use data from the English Longitudinal Study of Ageing (ELSA), a representative panel survey of the non-institutionalised over-50 population of England. Panel respondents are asked a battery of questions about their demographics, wealth, income, activities, spending and pensions. I use ELSA data from 2004 to 2018 comprising 7 biennial waves (Waves 2 to 9), and drop anyone born before 1940. Appendix B presents some descriptive statistics on the sample used.

To understand basic trends in labour supply I first consider women's labour force participation by age across cohorts with different SPAs. Figure 3 below plots the proportion

Figure 3: Proportion in labour force by birth cohort



of women in the labour force (i.e. working full-time, part-time, or unemployed) by age across different cohorts.

For pre-reform cohorts - i.e. women born before 1950 - the employment profile by age looks very similar, with a particularly sharp drop off at 60, the SPA for these cohorts[2]. However, for later cohorts, women seem to stay in the labour force longer. This suggests that the first-order effects of the reform are to delay women's retirement, in line with the evidence in Cribb, Emmerson, and Tetlow (2016) and Hentall-MacCuish (2025).

2.2.2 Prevalence and nature of mistakes

From 2006 (Wave 3), ELSA asked women respondents below the SPA two questions about their perception of the SPA. Respondents were asked "Do you know what age in years and months you will reach the SPA?" (and were then prompted to supply the details). Respondents were also asked "Do you know that the SPA for women is changing?".

Figure 4 plots people's responses as to their SPA, separately for different cohorts. The data are taken from Waves 3 and 4 of ELSA. In each case, the dotted red line shows the median true SPA for this cohort[3].

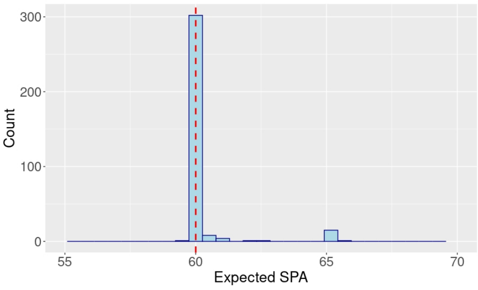
The 1949 cohort - the final pre-reform cohort - has SPA beliefs that are tightly bunched on the true SPA of 60. In subsequent cohorts, as the SPA increases (the red line shifts rightwards), there are three main types of respondents. In order of size, these are those who shift in line with the truth, those who still believe that the true SPA is 60, and

[2]The question of why there is so much bunching in retirement around the SPA is interesting and important. Cribb, Emmerson, and Tetlow (2016) and Hentall-MacCuish (2025) consider this question in detail in the UK context, with the former emphasising the importance of SPA receipt as a signal of when it is appropriate to retire, and the latter emphasising the importance of learning about the SPA.

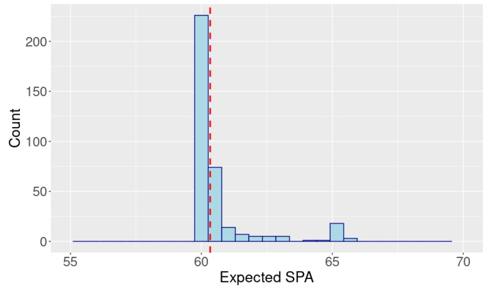
[3]Appendix A discusses how the true SPA measure for each individual is constructed.

Figure 4: SPA beliefs by cohort

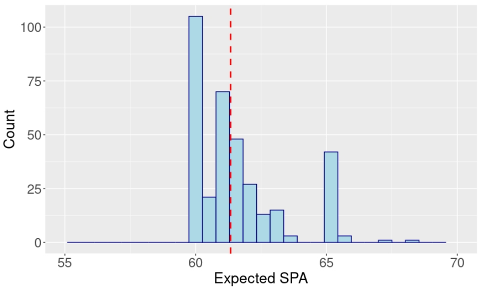
(a) Born 1949



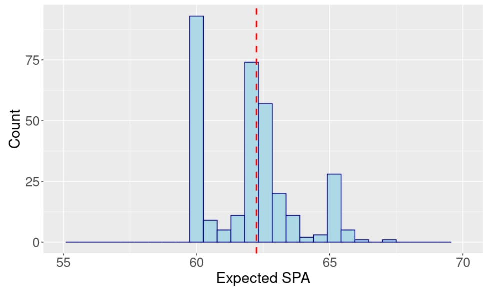
(b) Born 1950



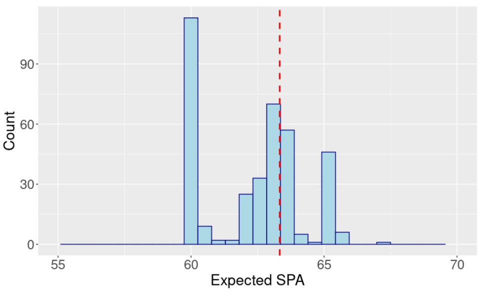
(c) Born 1951



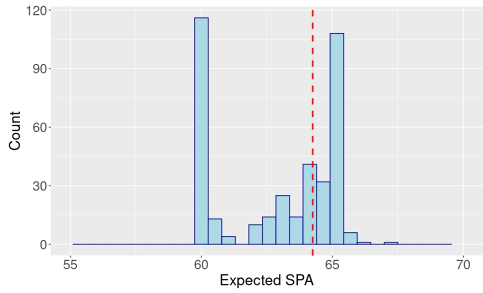
(d) Born 1952



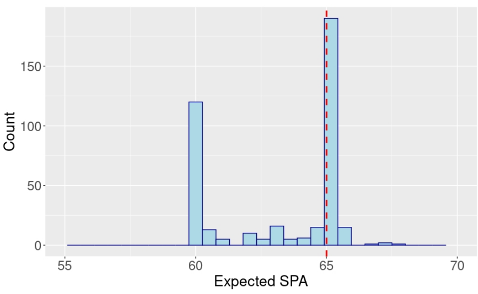
(e) Born 1953



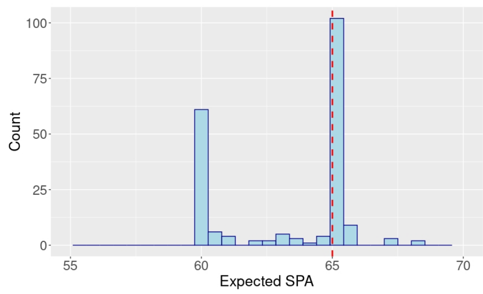
(f) Born 1954



(g) Born 1955



(h) Born 1956

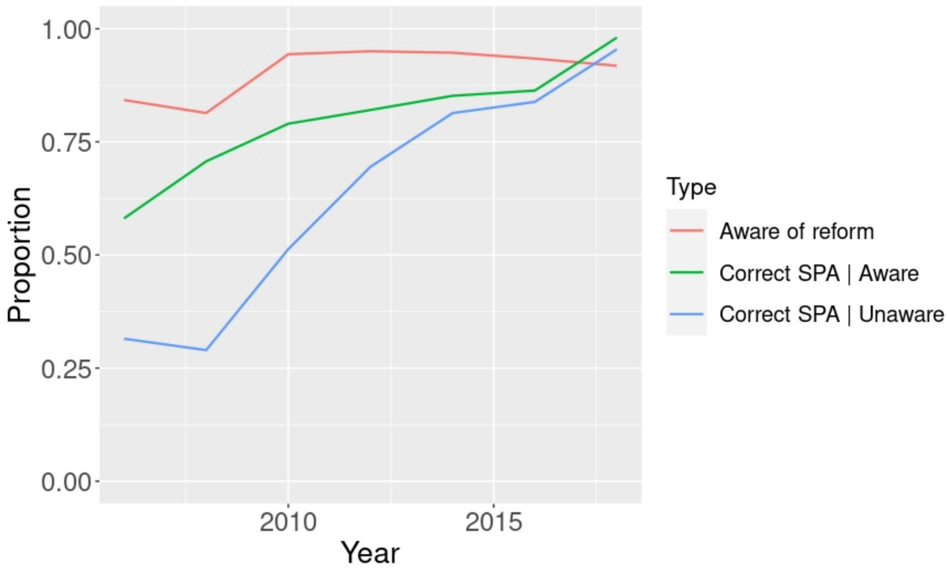


Notes - data taken from ELSA waves 3-4 (2006-2009). In each case, dotted red line represents median true SPA for this cohort under the regime in place at the time. Answers of a SPA > 70 or < 55 are omitted - these make up only 1% of answers.

those who overcorrect to believing that their SPA is higher than the true value, typically believing they have a SPA of 65.

As for how the correctness of beliefs changed over time, Figure 5 plots the proportion of people with correct beliefs[4] over time. In particular, I plot 3 lines: the red line is the proportion of women who were aware of the reform to the SPA (in the sense that they answered in the affirmative to the question "Do you know that the SPA for women is changing?"). The blue line is the proportion of people with correct beliefs conditional on being aware of the reform, and the green line is the proportion of people with correct beliefs conditional on not being aware of the reform. The sample from which the means are calculated is women who are below their SPA and whose true SPA is > 62. This second proviso is to ensure that women who continue to answer that they believe their SPA to be 60 even if it is actually higher will be deemed to have incorrect beliefs, given that I am defining "correct" beliefs to be those within two years of the truth.

Figure 5: Awareness of reform over time



Notes - means calculated from those respondents who are below the SPA and whose SPA > 62.

One clear pattern that emerges is that awareness of the reform in general terms was always very high, even back in 2006. There seems to have been a spike in awareness around 2010, plausibly because this was the first year that people actually experienced not being

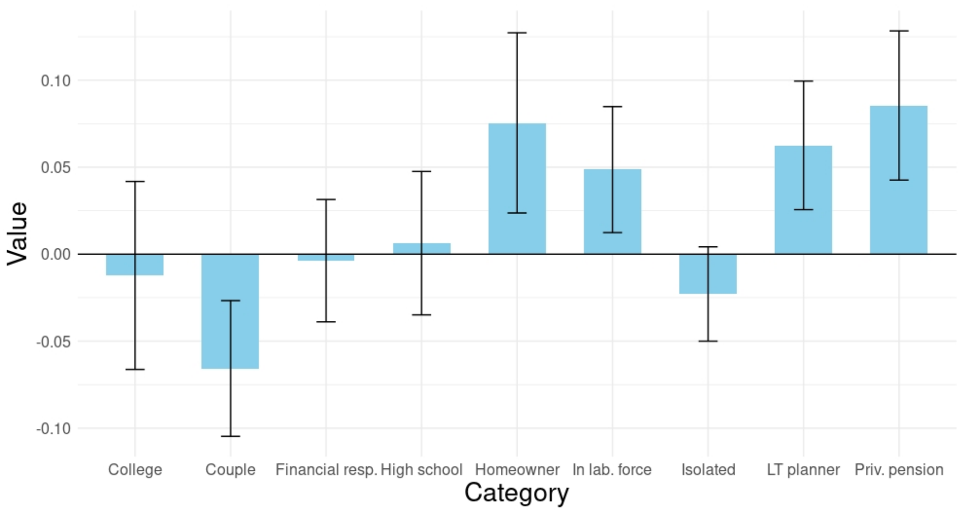
[4]In this case, I count a person's beliefs as being correct if they are less than 2 years out from the truth. So, if a person's true SPA is 62 and 3 months, then any answer from 60 and 3 months to 64 and 3 months is deemed as correct. This is obviously a generous definition of what it is to be correct. There are two reasons for this: firstly, in the public ELSA data only the respondent's year of birth, not date of birth, is provided. I impute respondents' month of birth, hence SPA, using a procedure set out in Appendix A, but to limit the importance of this imputation procedure to determining the results I focus on "big" mistakes which are clearly the result of the agent's SPA beliefs being incorrect rather than due to their imputed SPA being far from their true SPA. Similarly, by focussing on "big" mistakes, I set aside differences between expected SPA and true SPA which are plausibly due to things like rounding one's SPA to the nearest year or 6 months.

able to claim their state pension at 60. Correctness of beliefs (whether conditional on being aware or unaware of the reform) increases gradually over time.

However, it is striking that even among those who claim to be aware of the reform in general terms, a significant minority still hold incorrect beliefs about their SPA. For instance, among those who in 2006 claim to know that the SPA for women is increasing, still 42% have incorrect beliefs about their SPA. This suggests that it is not plausible to treat one's realisation about one's true SPA as an exogenous shock. Instead, most people were aware in general that the reform was taking place, and it is those who chose to do further research who were able to find out their true SPA.

Finally, to shed some light on the determinants of having correct beliefs, I regress a dummy for having correct beliefs on a set of RHS variables for Waves 3 and 4 (2006-09) for women below the SPA in those waves and who had data for all the regressors. The coefficients from the regression are displayed in Figure 6 , with the full regression table in Appendix B.

Figure 6: Coefficients from correct beliefs regression



Notes: OLS coefficients from a regression of a dummy for having correct beliefs on the set of RHS variables listed as well as age and YOB fixed effects. Data from ELSA Waves 3 and 4 (2006-09). Standard errors clustered at the individual level. The full regression table is presented in Appendix B.

Homeowners, those with private pensions, those in the labour force and those who described themselves as being long-term planners[5] were more likely to have correct beliefs. There is no strong association between correctness and education level (College or High school - the omitted variable is leaving high school at or below the age of 16), and no strong association between being the ELSA survey financial respondent and having

[5]In Wave 2, ELSA respondents were asked "In deciding how much of your income to spend or save, people are likely to think about different financial planning periods. In planning your saving and spending, which of the following time periods is more important to you?". I class as long-term planners all those who answered that their financial planning period was 5 years or above.

correct beliefs. Those respondents who claim to be socially isolated[6] are less likely to have correct beliefs, though this association is not significant at the 5% level. Finally, those in couples are less likely to have correct beliefs.

It is somewhat surprising that more educated people, and those in couples, are no more likely to have correct beliefs. One way of understanding these results is that while higher-educated people are plausibly more likely to be financially literate, they are also likely to be less reliant on the state pension to support them in old age, so there is less of an incentive to keep track of when exactly their state pension will arrive. Similarly, while couples might be expected to receive more information because of having an extra pair of ears and eyes in the household, the woman's state pension makes up a smaller proportion of total household income in retirement compared to single households.

2.3 Responses to realising mistakes

As the ELSA dataset follows individuals over time, it is possible to track how individuals' behaviour changes after they switch from having incorrect beliefs to having correct beliefs. I exploit this information to estimate a set of event studies on choice variables of interest.

Of course, it is difficult to interpret these switches as being exogenous information shocks: people endogenously decide whether to investigate their pension status. Indeed, the evidence from Figure 5 suggests that many more people knew that a reform in general was taking place than knew exactly how the reform would apply to them which could be interpreted as many people deciding not to pursue more information on how the reform applied to them. This suggests that there would be selection into those who did the research and therefore received the information. Also, certain choices agents make like re-entering the labour market might expose them to more information, which would be difficult to distinguish from people acquiring information and then entering the labour market as they change their plans. As such, these event studies should be interpreted as giving a description of how choice variables changed around the time of someone switching from having incorrect to correct beliefs, rather than establishing a causal relationship.

For each choice variable of interest y_{iat} of individual i of age a at time t, I estimate the following regression:

$$y_{iat} = \sum_{j=\{-3,..,3\}} \beta_j D_{t-j} + \alpha_i + \gamma_{at} + \delta_a \times I(\text{In LF in '06})_i + \lambda_a \times I(\text{Spouse in LF in '06})_i \quad (1)$$

The event is realising one's mistake, i.e. the first time i is observed with incorrect beliefs in $t-1$ and correct beliefs in t, then i is considered to have realised their mistake

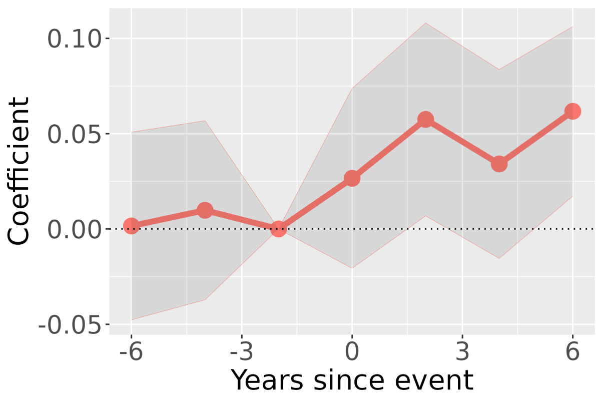
[6]ELSA respondents are asked "How often do you feel isolated from others?". I classify as socially isolated all those who answer "Some of the time" or "Often".

at t.

Also included as regressors are individual fixed effects α_i, age by time fixed effects γ_{at}, and interactions between age dummies and dummies for whether the individual/their spouse (if any) was in the labour force in 2006, the first observation in the data. Note that the age by time fixed effects will control for people being above or below either the old or new SPA for their particular cohort. The reason for including differential age trends by whether an agent or their spouse was originally in the labour force in 2006 is that we might expect different slopes in the relevant outcome variables by age depending on degree of attachment to the labour force[7]. In Appendix B I present the corresponding figures for this section but without these trends by original labour force attachment; the "jump" around the point of realisation is similar but there are pre- and post-trends.

I estimate the model of Equation 1 for a range of outcome variables. In each case, the relevant sample is women born between 1945 and 1956 who appear in the Wave 3, the first wave of data that I use, meaning I capture 5 pre-reform cohorts as well as all the cohorts whose SPA was on the transition path between 60 and 65. Figure 7 plots the estimated coefficients from the regression in Equation 1 where the outcome variable is a dummy for labour force participation on the LHS.

Figure 7: Event study: labour force participation



Notes: standard errors clustered at individual level.

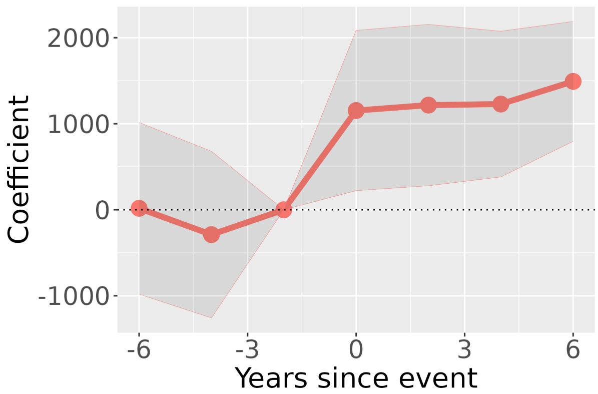
The results suggest that there is an uptick in labour force participation for women after they realise the truth of their SPA, though the standard errors are large.

Figure 8 plots the estimates where the LHS variable is the individual's annual earnings.

Again, there seems to be an uptick in earnings from labour around when agents realise the truth about their SPA.

[7]For instance, suppose there are two groups of people: those more attached to the labour force and those less attached. Suppose that as they get older the probability of both groups working decreases by the same percentage amount every year. This means that the absolute difference in working probability between the two groups would mechanically shrink, creating a trend in the absolute difference in working probability between the two groups that imposing a common age trend would not eliminate. Instead, I impose separate age trends by original labour force status as a proxy for attachment to the labour force.

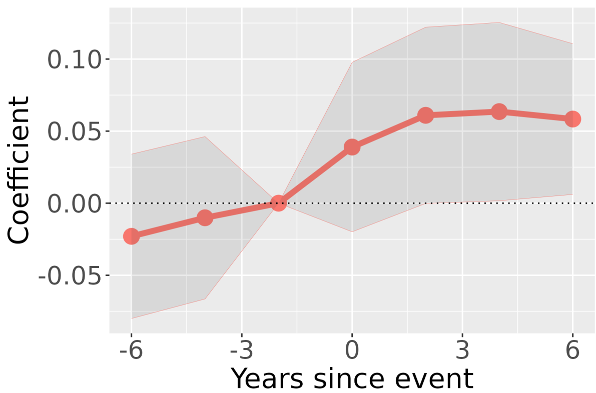
Figure 8: Event study: annual labour earnings



Notes: standard errors clustered at individual level.

Finally, Figure 9 plots the estimates where the LHS variable is spouse's labour force participation and annual earnings.

Figure 9: Event study: spouse's labour force participation



Notes: standard errors clustered at individual level.

Again, spouse's labour force participation seems to increase after the mistake about the SPA is realised, though there are some pre-trends here as well.

However, there is no corresponding uptick for other variables of interest. Figure 10 below plots the event studies where the outcome variables are log annual food spending, a dummy for being a homeowner, a dummy for having over £10k in financial wealth and a dummy for financially struggling[8].

In no case is there a striking uptick or downtick in the outcome variable around the moment of realisation. As such, to the extent that we are able to interpret these event studies as measuring responses to realising one's pension will arrive later than expected,

[8]ELSA respondents are asked "Looking at this card, please say how often you find you have too little money to spend on what you feel your needs are?", where the options are "Never", "Rarely", "Sometimes", "Often" or "Most of the time". I classify as financially struggling anyone who answers "Sometimes", "Often" or "Most of the time".

Figure 10: Event studies: other outcome variables

Notes - standard errors clustered at the individual level.

most of the response is loaded on changes in labour supply rather than a drawing down of assets or a reduction in consumption, and that this response is able to protect agents from financially struggling.

However, as outlined above, the significant problem with interpreting these results causally is that the arrival of information is in part a result of agents endogenous decisions to do their own research. For this reason, it is important to model the incentives agents face to do their own research.

3 Model

3.1 Model overview

The decisionmaker in the model is a household, either a single woman or a married woman-man couple. The household's age is set to be the same as the age of the woman. The household starts the model at age 50 and dies at age 85. If there is a husband in the household, his age is assumed to be 2 years greater than that of the woman, matching median age differences in the data. Time is discrete.

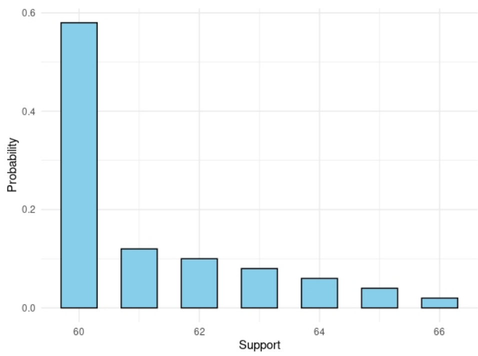
In every period, the household is either attentive or inattentive to the true SPA. If the household is attentive, then the model collapses to a standard life-cycle model with a unitary household where each period the household makes a discrete labour supply choice and a continuous consumption choice, saves in a risk-free asset, and receives state pension income from the government from the true SPA onwards, which they fully anticipate.

If the household is inattentive then then they face an extra choice at the beginning of each period: they choose their level of attention $m_t \in \{0, 1\}$, which can be intuitively thought of as the household "doing their research" once and for all. The benefit of doing research is that the household resolves their uncertainty about their true SPA and becomes attentive, enabling better planning for retirement; the cost of doing research is that the household must pay a cost of attention which depends on their state variables. Once a household does their research once, they stay attentive forever, so the model again collapses into a more standard life-cycle model with consumption and labour choices.

3.2 Beliefs

A key element of the model is a household's[9] beliefs about their true SPA. Let the belief of an inattentive agent be given by g_0, a vector of probabilities associated with each possible value of the true SPA. To keep the problem tractable, I assume that the agent believes that the SPA can only take on integer values between 60 and 66 inclusive. For instance, g_0 might be represented by the probability mass function below:

Figure 11: Example g_0



In this case, the inattentive agent is confident that the true SPA is 60 but allows some possibility that it will take on higher values.

By contrast, the attentive agent is certain of what the true SPA is. Their belief is given by $\bar{g}$, a degenerate probability mass function which assigns a probability of 1 to the actual true SPA being the SPA.

If the agent were to do their research and become attentive, their beliefs would switch from g^0 to $\bar{g}$. In the inattentive state, they therefore have beliefs about what their beliefs will be should they pay attention, given by g^0. For instance an inattentive agent might think that there is an 80% chance that if they pay attention they will subsequently be

[9]Given that, at least in earlier waves of ELSA, only women were asked about their SPA, I do not differentiate between the beliefs of the woman or a man in a couple household, and will refer to agents'/households' beliefs interchangeably.

certain that the true SPA is 60. Thus the prior belief g^0 will play a key role in determining the inattentive agent's incentives to do their research.

3.3 Resources

Households earn wages in the labour market and save in a risk free asset. Let z_t be a collection of state variables and let c_t and L_t be the household's consumption and labour market choices, outlined in Section 3.4 below. The household budget constraint is:

$$a_{t+1} = (a_t + h_l(L_t, z_t) + h_{nl}(z_t) - c_t)(1 + r) \tag{2}$$

where a_t is wealth, $h_l(L_t, z_t)$ is labour market income. $h_{nl}(z_t)$ is non-labour market income and r is the real interest rate.

If the woman in the household does not work in the labour market, she earns nothing; otherwise, she earns a wage $w_f(z_t)$. Similarly, if there is a man in the household and he works then earns a wage $w_m(z_t)$. Household labour income $h_l(z_t)$ is the sum of wages across the household members. In any given period, wages will depend on household members' demographics as well as temporary productivity shocks, independent across household members.

As for non-labour income, household members receive their state pensions from their respective SPAs. Some household members may also receive private pension income from that pension's normal retirement age. Households also receive a residual amount of non-labour income that does not come from pensions, which captures capital income, government transfers and other sources of income. For full parameterization of both the labour market and non-labour-market income functions see Section 3.5 below.

3.4 Choices

3.4.1 Consumption choice

Working backwards within a given period, the final choice that a household makes is consumption, c_t. Conditional on state variables z_t, labour choice L_t, and current belief about the SPA g_t, they choose c_t to maximise:

$$v_t^c(c_t|L_t, z_t, g_t) = u(c_t, z_t) + \beta E_g \left[V_{t+1}^m(z_{t+1})|L_t, c_t\right] \tag{3}$$

where $u(c_t, z_t)$ is the instantaneous utility function for consumption and $V_t^m(\cdot)$ is the value function from the attention choice, defined below. Thus, as is standard, households choose consumption to maximise the expected present discounted value of lifetime utility, where the expectations are taken relative to their current beliefs g_t.

3.4.2 Labour choice

Prior to the consumption choice the household makes a discrete labour choice. Conditional on state variables z_t and current belief g_t, the agent chooses one of four options for labour supply: {Neither wife nor husband works; Wife does not work but husband does; Wife works but husband does not; Both work}. Denote these four possible choices as $L_t = \{1, 2, 3, 4\}$. For single women, only the first and third of these are available as choices.

Let $V_t^c(L_t, z_t, g_t) = \max(v_t^c(c_t|L_t, z_t, g_t))$, i.e. the value function from the optimal consumption choice. The utility associated with labour choice L_t is given by:

$$v_t^L(L_t|z_t, g_t) = V_t^c(L_t, z_t, g_t) - \omega(L_t, z_t) + \epsilon_{L_t t} \tag{4}$$

Thus, the utility from the labour choice is the value function from the consumption choice conditional on that labour choice, less cost of labour $\omega(L_t, z_t)$, plus an iid Type 1 Extreme Value preference shock with scale parameter σ_ϵ[10]. The cost of supplying labour is allowed to depend on state variables z_t because, for instance, it might be more costly to work in t if one did not work in $t-1$, because of start-up costs.

3.4.3 Attention choice

Prior to the labour choice, if the agent is inattentive, they make an attention decision $m_t \in \{0, 1\}$. As set out above, this is tantamount to the agent deciding whether to do their research "once and for all" on the issue of the SPA and resolving any uncertainty; in other words, being attentive is an absorbing state.

Let $V_t^L(z_t, g_t) = E_{g_t}[\max(v_t^L(L_t|z_t, g_t)]$, i.e. the value function from the optimal labour choice. The utility of setting $m_t = 1$ is given by:

$$v_t^m(1|z_t) = E_{g^0}[V_t^L(z_t, \bar{g})] - \kappa(z_t) + \xi_{1t} \tag{5}$$

and of setting $m_t = 0$

$$v_t^m(0|z_t) = V_t^L(z_t, g^0) + \xi_{0t} \tag{6}$$

where $\kappa(z_t)$ is the cognitive cost of paying attention and ξ_{it} is another iid Type 1 Extreme Value preference shock, independent of the labour preference shock, with spread parameter σ_ξ.

To close Equation 3 above, we need to specify $V_t^m(z_t)$. For inattentive agents, this will be $V_t^m(z_t) = E_{g_0}[\max(v_t^m(m_t|z_t))]$, i.e. the value function from making the optimal

[10] I assume that the labour preference shocks are realised only after the agent makes their attention choice, prior to the labour choice. Thus, when the agent is making their attention choice, they only know the probabilities of their future labour supply.

attention choice. For attentive agents, as they have no attention choice to make, we have that $V_t^m(z_t) = V_t^L(z_t, \bar{g})$. In the terminal period, there is no future utility, so $V_{t+1}^m(z_{t+1}) = 0$.

Equation 5 suggests that it is the expectation of the value function from the labour choice which is key for assessing agents' incentives to pay attention. This is because an inattentive agent is uncertain over what the degenerate distribution $\bar{g}$ is, with different values for $\bar{g}$ resulting in different values for the value function. Thus, the fact that inattentive agents evaluate this expectation according to their original belief distribution g^0 is key.

I assume that if the inattentive agent reaches the age of 60, and the true SPA for this agent is indeed 60, then their uncertainty is resolved costlessly: they become attentive without incurring attention cost $\kappa(z_t)$. Otherwise, they are forced to pay cost $\kappa(z_t)$ and become attentive. This captures the fact that if an inattentive agent reached their expected SPA and ended up receiving their pension, their inattention would be costlessly resolved, whereas the inattentive agent who did not receive their pension at their expected SPA would be forced into doing their own research.

3.4.4 Discussion

Another way of stating the problem of whether to pay attention for the inattentive household is that the inattentive household chooses to do their own research iff:

$$\underbrace{E_{g^0}[V_t^L(L_t|z_t, \bar{g})] - \kappa(z_t) + \xi_{1t}}_{\text{Value of resolving uncertainty}} > \underbrace{V_t^L(L_t|z_t, g^0) + \xi_{0t}}_{\text{Value of delaying resolution of uncertainty}} \tag{7}$$

This condition is intuitively more likely to hold if:

- The cost of attention $\kappa(z_t)$ is lower. For instance, people in couples plausibly have a lower cost of attention because their is an extra person in the household who might come across information on SPA changes, so other things being equal we might expect these people to pay more attention.

- The "stakes" of the problem are higher, i.e. optimal behaviour is highly sensitive to when the true SPA is, and/or utility is very sensitive to optimal behaviour. For instance, a woman with a private pension has an extra source of income in the household, so is better insured against future shocks to household income: the woman's state pension income is a smaller fraction of total household income in retirement. This means that the stakes of the issue are lower for such households, and so other things being equal we might expect these people to pay less attention.

- There is more uncertainty in the original prior belief g^0. If inattentive households are originally less certain that the true SPA is 60 then they will give more weight to the “bad” outcome where they have to wait several years for their pension, under which carrying on the same path of consumption and labour as before might be highly suboptimal. They then they will have more of an incentive to do their research and find out what the true SPA is.

- Most simply, there is a large positive net preference shock for paying attention $\xi_{1t} - \xi_{0t}$. These shocks could be interpreted as genuine iid variation in preferences for doing research. However, they could also be interpreted as exogenously occurring opportunities to receive information - like an article appearing in a local newspaper - which e.g. couples might be more likely to take on board because there is an extra set of eyes in the household[11].

3.5 Functional forms and parameterisation

3.5.1 Belief parameters

The key object for agents' beliefs is the original belief distribution g_0, which is the probabilities that inattentive agents attach to the true SPA taking on certain values between 60 and 66. From the survey data, we only know what inattentive agents consider their true SPA to be, but we do not know the certainty with which they hold this belief, or how likely they are to consider themselves to be wrong. To capture this potential uncertainty simply within the model, I impose, for $k \in \{60, 65\}$, that:

$$P(SPA = k + 1) = \lambda P(SPA = k) \tag{8}$$

where $P(SPA = k)$ is the agent's subjective probability under g_0 that the true SPA for them is at age k. This, combined with the assumption that $\sum_{k=60}^{66} P(SPA = k) = 1$, means that the entire distribution g_0 is determined by a single parameter λ, which captures the degree of uncertainty that agents have over the true SPA when inattentive. As $\lambda \to 0$, inattentive agents are certain that the true SPA is 60, and as $\lambda \to 1$, inattentive agents attach equal probability to the SPA being any age from 60 to 66.

3.5.2 Utility of consumption

I assume that utility from consumption takes the CRRA form:

$$u(c_t, z_t) = \frac{\left(\frac{c_t}{\chi(z_t)}\right)^{1-\theta}}{1 - \theta} \tag{9}$$

[11] Due to this ambiguity over the interpretation of shocks to the cost of paying attention, the welfare analysis in Section 5 will largely abstract from utility from attention and focus instead on utility from consumption and labour.

where $\chi(z_t)$ is the equivalence scale for consumption, which I set as 1 for singles and $\sqrt{2}$ for couples.

3.5.3 Disutility of working

The disutility of working is captured in parameter $\omega(L_t, z_t)$.

For each individual household member i, let $L_t^i \in \{m(\text{ale}), f(\text{emale})\}$ the household member's labour supply at t. Let $\omega_i(L_t^i, z_t)$ be that individual's contribution to total household disutility of working $\omega(L_t, z_t)$. Then, I impose that $\omega_i(L_t^i, z_t)$ takes the form:

$$\omega_i(L_t^i, z_t) = \begin{cases} \omega_0 + \omega_{age} \times age_{it} + \omega_{age2} \times age_{it}^2 + \omega_{prevwork} \times L_{i,t-1} & \text{if } L_t^i = 1 \\ 0 & \text{otherwise} \end{cases} \tag{10}$$

As such, the disutility of working depends on a quadratic in age and on whether the household member was working the previous period.

For single households, we have simply that $\omega(L_t, z_t) = \omega_i(L_t^i, z_t)$[12]. For couple households, I impose that:

$$\omega(L_t, z_t) = \begin{cases} \omega_f(L_t^f, z_t) + \omega_m(L_t^m, z_t) + \omega_{joint} & \text{if } L_t^f = 0 \ \&\ L_t^m = 0 \\ \omega_f(L_t^f, z_t) + \omega_m(L_t^m, z_t) & \text{otherwise} \end{cases} \tag{11}$$

In other words, for couple households, the overall disutility of labour is the sum of individual members' disutilities plus an extra interaction term for the case where neither household member is working, which would allow the model to capture potential benefits of both household members retiring at the same time, as discussed in e.g. Lalive and Parrotta (2017).

3.5.4 Cost of paying attention

The cognitive cost of paying attention is captured in $\kappa(z_t)$. I parameterise it as follows:

$$\kappa(z_t) = \kappa_0 + \kappa_{HS} \times highschool + \kappa_{col} \times college + \kappa_{couple} \times couple + \kappa_{prevwork} \times L_{t-1}^f \tag{12}$$

Thus, the cost of paying attention is a linear function of education level, couple status, and whether the woman in the household worked the previous period.

[12]Where $L_t = 1$ if $L_t^i = 0$ and $L_t = 3$ is $L_t^i = 1$, as L_t corresponds to the set {Neither wife nor husband works; Wife does not work but husband does; Wife works but husband does not; Both work} whereas L_t^i corresponds to the set {Household member i does not work; Household member i} .

3.5.5 Wages and non-labour income

In this subsection I discuss the parameterization of the wage and non-labour income processes.

I assume the wage on offer for household member i every period is:

$$w_i(z_t) = \exp(\gamma_0 + \gamma_{age} \times age + \gamma_{age2} \times age^2 + \gamma_{HS} \times highschool_i \\ + \gamma_{col} \times college_i + \gamma_{male} \times male_i + \gamma_{prevwork} \times L^i_{t-1} + \eta_{it}) \quad (13)$$

where

$$\eta_{it} = \rho\eta_{i,t-1} + \nu_{it} \quad (14)$$

is a persistent productivity shock for agent i, modelled as an AR(1)[13]. The shock component ν_{it} is iid over time and across household members and has distribution $N(0, \sigma^2_\nu)$.

Households have three potential sources of non-labour income: state pension, private pension, and other income, with this latter category capturing other government transfers and capital income. Households are assumed to have private pensions if and only if they are ever observed receiving or contributing to private pensions in the data.

I assume state pension income is a flat amount, which is received from the household member's true SPA onwards: 65 for men and some age between 60 and 65 for women, depending on cohort. The flat amount is taken from mean state pension income in the data.

For those with private pensions, private pension income is also a flat amount, and is received from age 60 for women and age 65 for men. I allow private pension income to differ by the education status of the household member and the couple status of the household, and use mean private pension income received by these demographic groups in the data.

Finally, other income is received every period at a flat rate, which I allow to differ by household couple status and by the education levels of wife (and husband, if relevant). The flat rate is then given by the mean non-labour and non-pension income received in the data by households with the relevant demographics.

Then, household non-labour income is simply given as the sum of these three income types across household members.

[13] When it comes to solving the model, in order to model the AR(1) part of the process, I use the Rouwenhorst method (Kopecky and Suen 2010) to discretize the AR(1) and convert it into a Markov process.

3.5.6 Model solution

The time-varying state variables of the model are the household's age, liquid wealth, beliefs at the start of the period, productivity shock of woman (and husband, if any) and labour supply previous period of woman (and husband, if any). The non-time-varying state variables are then the couple status of the household, education of the woman (and husband, if any)[14] and whether or not the woman (and/or husband) have a private pension.

The model is solved via backwards induction. First, for each candidate SPA between 60 and 66, I solve the model for every combination of state variables, imposing that agents are certain that the true SPA is the candidate SPA. Then, I use the value functions from this process as inputs for solving the problem of the inattentive agent, constructing the equivalents of Equations 5 and 6 to determine the incentives for the inattentive agent to pay attention when they are below the SPA.

4 Estimation

Estimation takes place using the 1945-56 birth cohort ELSA sample of women and their husbands (if any). I select those women who were present in Wave 3 (2006) and who have information on their couple status, work status and income for each subsequent wave that they answer. I abstract from changes in couple status and assume that those single/coupled in the first wave will remain so for the entire model. Appendix B presents more detail on sample construction and descriptive statistics for the sample used for estimation.

I use as the relevant wealth variable the sum of financial wealth for the household, meaning I exclude housing wealth. The reason for this is that a very large component of total wealth of English households is taken up by housing wealth yet downsizing or otherwise accessing this housing wealth is rare (Banks, Blundell, et al. 2012; Blundell, Crawford, et al. 2016), meaning that practically the wealth that households will have access to in order to smooth any income shocks will be their more liquid financial wealth. Moreover, modelling housing and financial wealth separately would severely complicate the model. For this reason, I focus only on financial wealth.

4.1 Parameters from outside the model

Some parameters are set outside of the model for convenience. I assume that the real interest rate r is constant at 2% and that the discount factor is $\beta = 0.975$. I set the CRRA parameter θ equal to 2.

[14]There are three separate categories for education, namely leaving high school at or below 16, having a high school education and having a college education.

As for the state pension ages for each cohort, to make the problem tractable I divide the data into 6 2-year birth cohorts, from those born 1945-46 (Cohort 0) to those born 1955-56 (Cohort 5). I set each agent's SPA as the median SPA for their cohort according to the regime in place in 2006, the first wave of the data[15].

As outlined in Section 3.5.5, state pension, private pension and other income sources are set at their mean levels in the data by demographic group.

4.2 Parameters estimated inside the model

The parameters to estimate inside the model are summarised in Table 1 below. There are 22 parameters to estimate in total.

Table 1: Parameter Descriptions

Parameter	**Description**
Work penalty parameters	
ω_0	Work penalty: constant
ω_{age}	Work penalty: linear age trend
ω_{age2}	Work penalty: quadratic age trend
$\omega_{prevwork}$	Work penalty: worked previous period
ω_{joint}	Work penalty: taking leisure at same time as spouse
Wage parameters	
γ_0	Log wage: constant
γ_{age}	Log wage: linear age trend
γ_{age2}	Log wage: quadratic age trend
$\gamma_{prevwork}$	Log wage: worked previous period
γ_{male}	Log wage: male
$\gamma_{highschool}$	Log wage: high school education
$\gamma_{college}$	Log wage: college education
Attention cost parameters	
κ_0	Attention penalty: constant
$\kappa_{prevwork}$	Attention penalty: worked previous period
$\kappa_{highschool}$	Attention penalty: high school education
$\kappa_{college}$	Attention penalty: college education
κ_{couple}	Attention penalty: in couple
Other parameters	
σ_ν^2	Variance of iid component of prod. shock
ρ	Persistence of prod. shock
λ	Decay factor for beliefs
σ_ϵ	Spread of preference shock for labour
σ_ξ	Spread of preference shock for attention

[15] As a result, the SPAs for Cohorts 0 through 5 are 60, 60, 61, 63, 65 and 65 respectively

Estimation takes place via the Method of Simulated Moments. I choose the parameter vector $\hat{\theta}$ to minimize the objective function:

$$(\bar{\mu} - \mu(\theta))'W(\bar{\mu} - \mu(\theta)) \tag{15}$$

where $\bar{\mu}$ is a vector of moments from the data, $\mu(\theta)$ is vector of corresponding moments generated by the model under parameter vector θ, and W is a weighting matrix.

I target 5 different types of moments:

- the mean labour earnings of women;
- the mean labour earnings of men;
- the proportion of women working;
- the proportion of men working;
- the proportion of women with correct beliefs about their SPA[16].

I target these moments for every period from 2006 to 2018, separately for each of the following subgroups:

- each birth cohort
- each education level (of both wife and husband, if any)
- each private pension status (of both wife and husband, if any)
- each labour force status in the previous period (for both wife and husband, if any)
- single vs. married women

I drop any moment from the estimation where there are fewer than 20 observations in the data to construct the relevant mean. I am left with 601 base moments. To these I add four supplementary moments to match:

- the coefficient on lagged log labour earnings in a regression of women's log labour earnings on lagged log labour earnings, individual fixed effects and age;
- the variance of the residuals from the above regression;
- the coefficient on a dummy for having correct beliefs about one's SPA in a regression of women's labour force participation on the correct beliefs dummy, individual fixed effects and age;

[16] I only consider women younger than 60 for this proportion because those 60 or above mechanically will have correct beliefs, because I assume that women's uncertainty is automatically resolved when they reach the old SPA

- the coefficient on a dummy for husband's labour force participation in a regression of a wife's labour force participation on the dummy for their husband's labour force participation, individual fixed effects and age (for couples only).

I discuss the reasons for including these moments in particular in Section 4.3 below.

The baseline weighting matrix I use is a diagonal matrix where the off-diagonal elements are 0 and the diagonal elements are the inverse of estimates of the variance of the corresponding data moment. This allows more precisely estimated data moments to receive more weight. However, to avoid the four supplementary moments from being swamped by sheer force of numbers by the 601 baseline moments, I reweight so that the supplementary moments receive 1/6 of the total weight and the baseline moments receive 5/6, reflecting the fact that the baseline moments represent 5 basic moment types, with each moment type receiving approximately the same weight as the supplementary moments taken together.

4.3 Identification

In this section I provide informal arguments for how the parameters to be estimated are identified from the data.

The parameters governing mean wages by age and by demographics are identified by differences in wages across ages and between different demographic groups. Then, the variance and autocorrelation of shocks to wages are identified by the first two supplementary moments described in the previous section, i.e. the variance of the residuals and the coefficient on lagged wages in wage regressions.

The parameters governing the utility penalties of working are identified by the proportions of agents working in the data. The fact that we observe people's wages when working mean that we can separate out people leaving work because the work penalty is increasing and because their wage is declining. Moreover, we can identify the parameter governing the utility bonus husbands and wives receive from not working at the same time using the fourth supplementary moment of the previous section, i.e. the coefficient on husband's labour force participation in a regression of wife's labour force participation on husband's participation, individual fixed effects and age.

The parameters governing the utility penalties of paying attention are identified by the proportions of agents in different demographic groups who have correct beliefs in the data. For instance, if married women are more likely to have correct beliefs even if the stakes of the paying attention are less for them (because their state pension is a smaller share of household income in retirement), then this would suggest that married women face a lower cost of paying attention than single women.

The two discrete choice shock spread parameters, σ_ϵ and σ_ξ, are scaled relative to the coefficient on the CRRA consumption function, which is normalised to 1. The larger is σ_ϵ (the labour preference shock), the smaller the gap in labour force participation rates between those with a large incentive to work and those with a smaller incentive to work, because more of the labour supply decision is explained by unobserved preference shocks. For instance, other things being equal, women without a private pension have a larger incentive to work than women with a private pension, because women with a private pension have an alternative income stream to rely on for retirement. Yet, women with a private pension have no difference in the utility penalty of working relative to women without. Thus, if women without a private pension are much more likely to work than women with a private pension, this suggests σ_ϵ is small, whereas if the gap is less pronounced, σ_ϵ would be larger. A similar argument applies to comparisons between more and less educated women, and women with and without a husband.

Similarly, to identify σ_ξ, we can match gaps in mean attention rates between different groups who are assumed to have the same utility penalties of paying attention, but have different incentives to pay attention for other reasons. In particular, it is assumed that women with a private pension will find it no more difficult to pay attention, yet women with a private pension have less of an incentive to pay attention to the SPA, so if the gap in attention rates between women with and without a private pension is very large, that would suggest σ_ξ is small.

Finally, the belief decay parameter governs how confident inattentive people are that the true SPA is 60. The more certain someone is that the true SPA is 60, then the less likely they will be to pay attention, and the bigger the correction in their behaviour after they realise. In contrast, the attention utility parameters will affect the cost of paying attention (hence the probability of someone paying attention) but will not affect how big the adjustment in behaviour will be after someone starts paying attention. Therefore, the bigger the adjustment in behaviour is following a realisation, the more certain an agent was in their beliefs beforehand, other things being equal.

4.4 Results

The results of the estimation are presented in Table 2 below.

The work penalty parameters capture variation between agents in the utility loss they suffer if they work. The burden increases quadratically as the agent ages, with the degree of the increase being identified by the drop-off in rates of working for a given wage as agents get older. Notably, the penalty associated with working is much less if the agent worked in the previous period, reflecting the fixed costs involved in starting work again having dropped out of the labour force.

To interpret the size of these coefficients, one can consider that if a given 50 year old had a 50% chance of working in a given period, then an agent who was entirely equivalent other than facing a 70 year old's cost of working today would instead work

Table 2: Estimation Results

Parameter	Estimate
Work penalty parameters	
ω_0 - Constant	2.326
	(0.009)
ω_{age} - Linear age trend	0.001
	(0.000)
ω_{age2} - Quadratic age trend	0.002
	(0.000)
$\omega_{prevwork}$ - Worked last period	-2.340
	(0.009)
ω_{joint} - Joint leisure	-0.188
	(0.013)
(Log) Wage parameters	
γ_0 - Constant	-0.571
	(0.011)
γ_{HS} - High school education	0.301
	(0.009)
$\gamma_{college}$ - College education	0.688
	(0.013)
γ_{age} - Linear age trend	-0.009
	(0.000)
γ_{age2} - Quadratic age trend	-0.000
	(0.000)
$\gamma_{prevwork}$ - Worked last period	0.180
	(0.004)
γ_{male} - Male	0.393
	(0.017)
Attention penalty parameters	
κ_0 - Constant	1.520
	(0.037)
κ_{HS} - High school education	-0.018
	(0.000)
$\kappa_{college}$ - College education	-0.267
	(0.004)
$\kappa_{prevwork}$ - Worked last period	-0.096
	(0.002)
κ_{couple} - Couple	-0.309
	(0.007)
Other parameters	
σ^2_ν - Variance of iid component of prod. shock	0.462
	(0.029)
ρ - Persistence of prod. shock	0.045
	(0.001)
λ - Belief decay parameter	0.353
	(0.011)
σ_ϵ - Type 1 EV spread parameter, labour	0.577
	(0.017)
σ_ξ - Type 1 EV spread parameter, attention	0.445
	(0.010)

Notes - estimation via MSM. See Section 4.2 for discussion of moments and weighting matrix used. Standard errors calculated from 20 bootstrap replications. For the calculation of age trends, note that ages were normalised such that age 50 in the data was age 0 in the model.

with only 19.4% probability. This comes from the fact that if Agent A has a 50% chance of working, then $v_A = 0$, where v_A is the value of working relative to not working, and thus if for Agent B $v_B = v_A - 0.001 \times (70-50) - 0.002 \times (70-50)^2$ and if $\sigma = 0.577$ is the spread parameter for the relevant Type 1 EV shock, then the probability of B working is $P_B = \frac{\exp(v_B/\sigma)}{1+\exp(v_B/\sigma)} = 0.194$. Similarly, if Agent A was identical to Agent B apart from the fact that Agent A had worked the previous period, and Agent A had a 50% chance of working today, then Agent B would have only a 1.7% probability of working today.

The ω_{joint} parameter captures the extent to which couples receive a utility boost if they are not working at the same time; in this case, if Agent A has a 50% chance of working when their spouse is working, they will have a 41.9% chance of working if their spouse is not working, other things being equal.

The wage parameters capture the difference in log potential wages, or (approximately) the percentage difference in potential wages, between different groups. Those with a high school education receive 30.1% more in wages than those who left school at 16, whereas those with a college education receive 68.7% more. Wages decline with age, at a rate of approximately 0.9% per year, though notably there is no major quadratic trend here, suggesting that the key limiting factor of working late in the life cycle is the utility burden of working rather than low wages. Again, those who worked in the previous period receive 18% higher wages, and men receive 39.3% higher wages than women.

The attention penalty parameters capture the utility loss of paying attention and "doing one's research" on the reforms to the state pension age. In other words, these parameters capture the cost of attention for different groups of women[17]. High-school educated women face similar costs of attention to women who left school at 16, but women with a college education have notably lower costs. Using the same approach as before, if a woman who left school at 16 had a 50% chance of becoming attentive in a given period, then a woman who was identical apart from the fact that her attention costs today was that of a high school educated woman would have a 51.0% chance of paying attention, and a woman who had an attention cost today of a college-educated woman would have a 64.5% chance of paying attention. Those who worked in the previous period have slightly lower costs of paying attention, and those in couples have significantly lower costs.

The variance and persistence of the productivity shock are estimated to match the variance and persistence in the wage data. Notably, productivity shocks have little persistence. The belief decay parameter captures how sure inattentive agents are that their true SPA is 60. The value of 0.353 means that for an inattentive agent, $Pr(SPA = k+1) = 0.353 Pr(SPA = k)$, for k between 60 and 65. Finally, the Type 1 EV shock spread parameters capture how much *iid* variation in preferences over time there is which

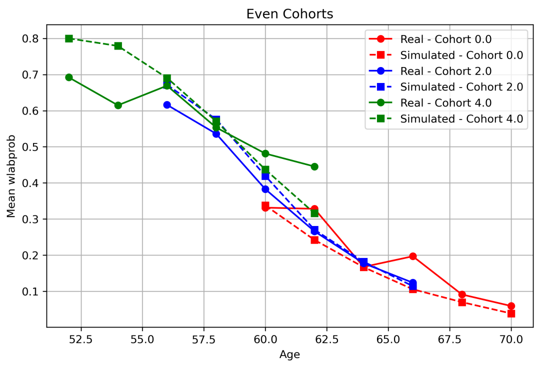
[17]The attention parameters are relevant to women only because only women are inattentive about their SPA, because men's SPA is not changing.

is not captured by the model: there is more unobserved iid heterogeneity in the labour choice than in the attention choice.

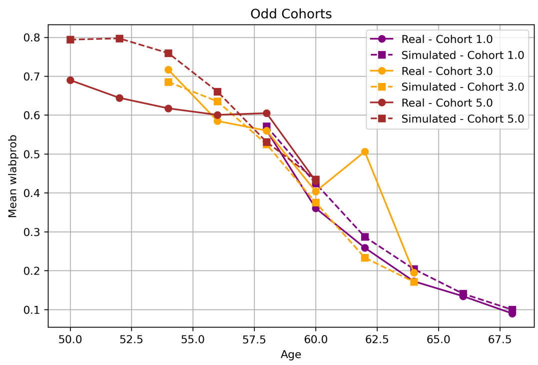
4.5 Model fit

Here, I present the targeted moments over time for each cohort as a whole to give a summary indication of model fit[18].

Figure 12 shows mean women's labour force participation in the data and in the model.



(a) Even-numbered cohorts

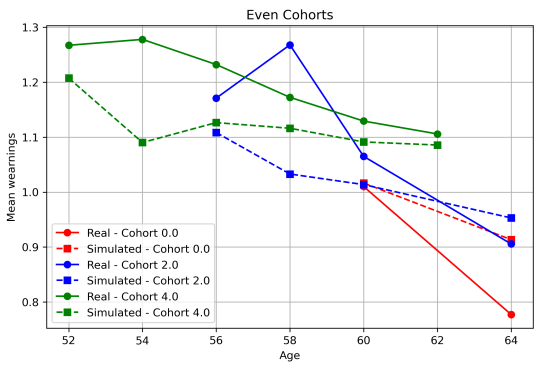


(b) Odd-numbered cohorts

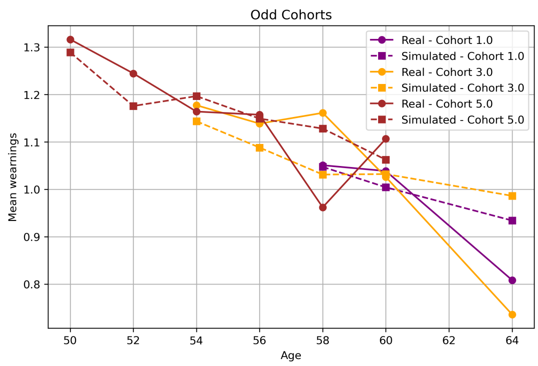
Figure 12: Model fit - women's probability of working

The fit is reasonably good, though the model tends to underestimate the proportion of women working relative to the data.

Figure 13 shows mean women's labour force earnings for odd-numbered cohorts for the data and model.



(a) Even-numbered cohorts



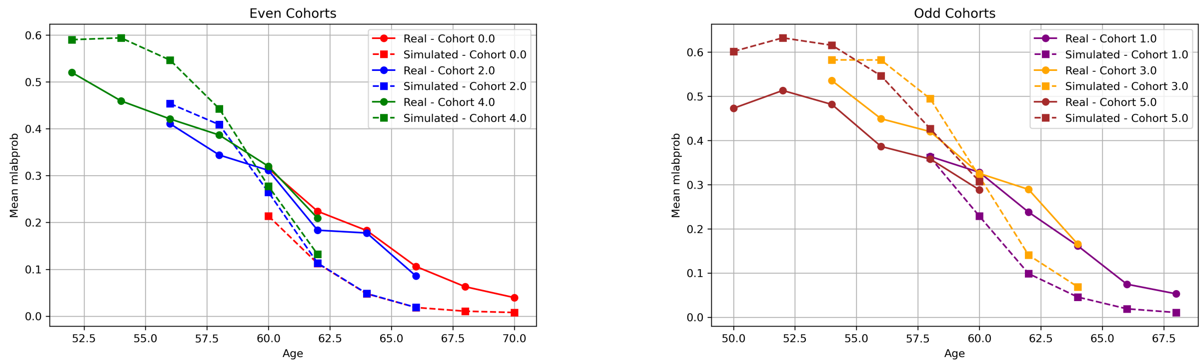
(b) Odd-numbered cohorts

Figure 13: Model fit - women's labour force earnings

[18]Note that as well as matching the targeted moments by cohort, I also match them by education status, private pension status, previous labour force status and couple status, as set out in Section X. For reasons of space, I focus only on the targeted moments by cohort as they provide the most useful summary measure of model fit

The fit here is also good in general though some data moments are missed quite badly. For instance, the model significantly overestimates how much those in Cohorts 1 and 3 earn if they work into their mid- to late-60s. The fact that the model can match these moments for the adjacent Cohort 2 suggests that this is not a systematic miss but rather is explained by the high variability of earnings.

Figure 14 shows mean men's labour force participation in the model and data.



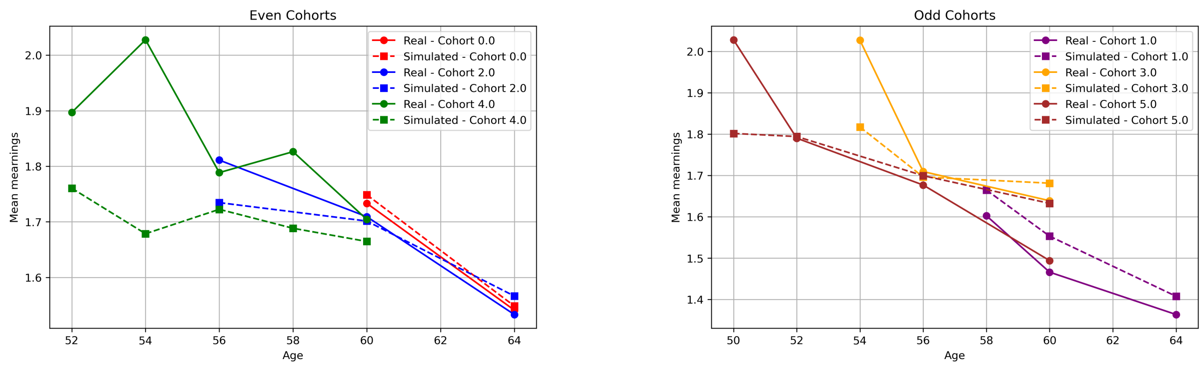
(a) Even-numbered cohorts

(b) Odd-numbered cohorts

Figure 14: Model fit - men's probability of working

There is a pattern in the moments that are missed: the model overestimates the labour supply probability of younger cohorts and underestimates the labour supply probability of older cohorts. This is plausibly due to the absence of cohort effects in the model, in particular differing cohort effects by gender. As there are more women than men in the model, the model focusses on matching as best as possible the fact that younger cohorts of women work relatively more, which is then imposed on the men in this model, so the model produces the same pattern of younger cohorts of men working more than older cohorts of men, even if this is not reflected in the data.

Figure 15 shows mean men's labour force earnings by cohort.



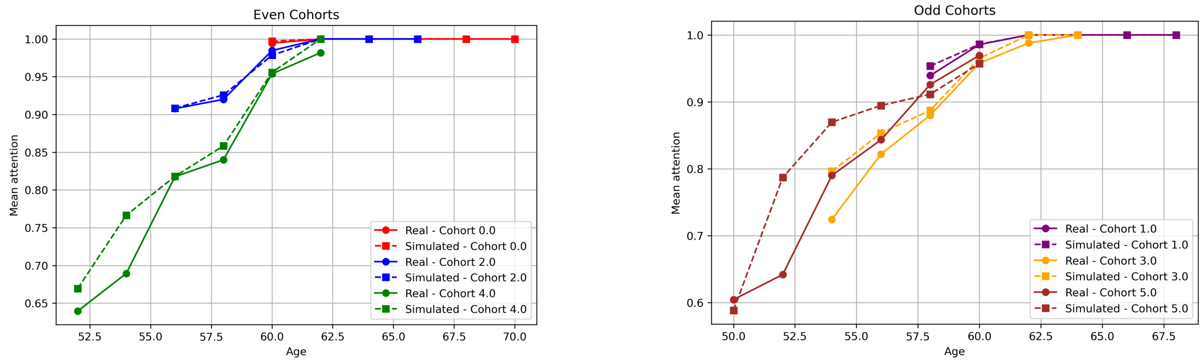
(a) Even-numbered cohorts

(b) Odd-numbered cohorts

Figure 15: Model fit - men's earnings

There are some notable misses for some cohorts - in particular, the model seems to underestimate the earnings of men in Cohort 4, particularly in their early 50s - but for most cohorts the fit is reasonably good.

Figure 16 shows the proportion of households who are attentive to the SPA changes.



(a) Even-numbered cohorts

(b) Odd-numbered cohorts

Figure 16: Model fit - proportion attentive

The younger cohorts in the model become attentive somewhat sooner than those in the data, but the fit in general is good.

Figure 17 shows the supplementary moments:

1) The coefficient on a dummy for being attentive in an OLS regression with the woman's labour supply decision on the LHS, with controls for age and individual fixed effects;

2) The coefficient on husband's labour supply in a regression with wife's labour supply on the LHS (for married couples only), with controls for age and individual fixed effects;

3) The coefficient on lagged log wage (2 periods ago)[19] in a regression with the woman's log wage on the LHS, with controls for age and individual fixed effects;

4) The variance of the residuals from the regression in 3).

The fit here is generally good. Notably, the model is able to match closely how agents' labour supply changes when they become attentive, suggesting that the model is capturing the degree to which agents have to change their behaviour once they realise they have made a mistake in their pension planning. The only notable miss is for the coefficient on the lag of log wage, where the model coefficient is less negative than the data coefficient.

[19] As ELSA waves are biennial but each period in the model is a year, the regression using model-generated data needs to use lagged log wage from 2 periods ago to be comparable with the original ELSA data.

Figure 17: Supplementary moments

Notes: error bars represent 95% confidence intervals

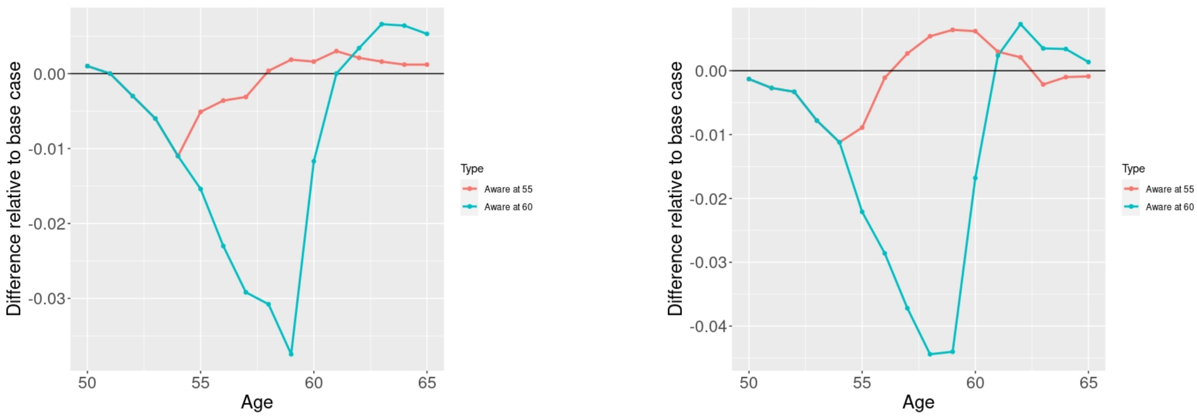
5 Welfare analysis and counterfactuals

5.1 How do people change their labour supply when they realise their mistakes?

With the estimated model in hand it is possible to generate truly exogenous shocks to agents' beliefs and analyse how they respond in terms of their labour supply, without the endogeneity issues discussed in Section 2.3. This allows us to assess how people change their labour supply when they realise they have made mistakes in their retirement planning.

To this end, I simulate the labour supply of agents over time from age 50 in 2006 to age 65 in 2021, and who are facing a SPA of 65, under three separate assumptions: a) all agents are aware throughout of the true SPA, b) all agents are unaware until the age of 55, when all become aware and c) all agents are unaware until the age of 60, when all become aware. I then calculate the percentage point difference in labour supply under assumptions b) and c) relative to the labour supply under assumption a). The results are presented in Figure 18.

The unaware agents start reducing their labour supply (of the woman in the household and the husband, if any) sooner than the aware agents, because they are over-optimistic about their income in retirement, which creates a widening gap in the labour supply of aware and unaware agents. When agents realise at 55, they increase their labour supply and eventually provide more labour than the agents who were aware from the start. However, the increase in labour supply is not very drastic as they realise 5 years before they could have received any state pension income even under the most optimistic



(a) Women

(b) Men

Figure 18: Probability of working relative to base case

outcome. For those who realise only at age 60, however, the change in labour supply is more dramatic, switching from working 3 or 4 percentage points less than the aware agents to working around a percentage point more. Thus, the model suggests there would be changes in labour supply behaviour after agents realise they have been overoptimistic about their income in retirement, but the changes are substantive only in the cases where agents realise their over-optimism close to retirement.

5.2 Who loses out the most from mistakes in retirement planning?

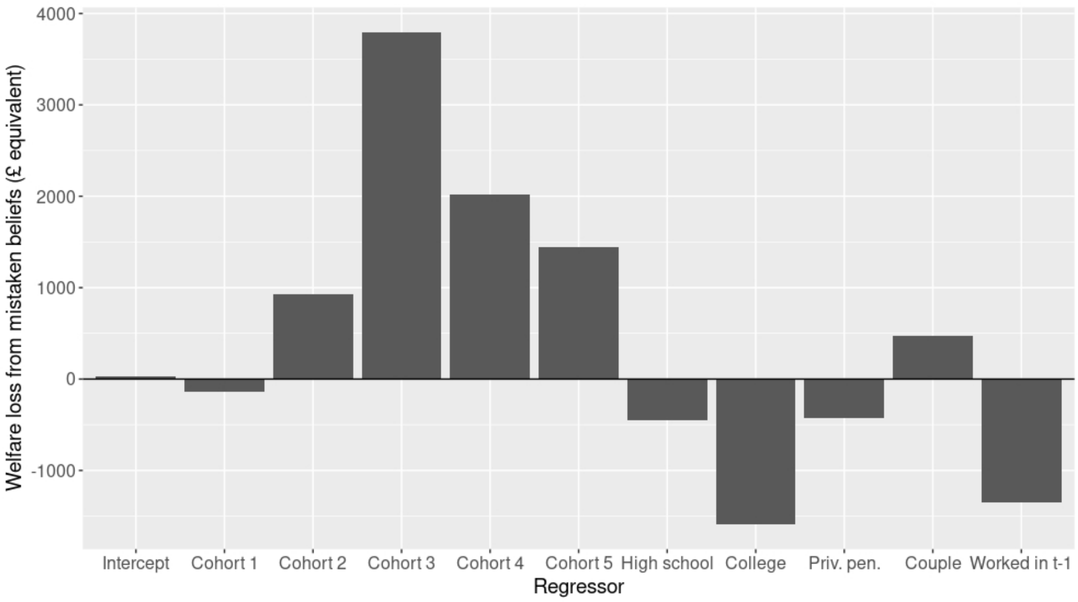
To analyse the welfare effects of mistakes in retirement planning, I construct a counterfactual sample of agents' labour supply and consumption behaviour, imposing that everyone is always aware of the reform. In other words, in 2006 when the simulation starts, all agents are aware of the reform. I then calculate the difference in experienced labour and consumption utility for the counterfactual agents versus the agents in the baseline model[20].

To provide a money-metric measure of utility losses from mistaken beliefs, I calculate for each inattentive agent in the data how much more wealth they would have to start the simulation with to be indifferent ex post between this and starting off the model attentive with the original amount of wealth, taking into account only experienced utility from consumption and labour. I then interpret this required compensating wealth as the money-metric welfare loss associated with having mistaken beliefs.

[20] I focus on experienced utility from labour and consumption because utility from attention - i.e. attention preference shocks, and the costs incurred from doing one's own research - is mechanically linked to the presence of inattention, and insofar as attention preference shocks can be interpreted both as preference shocks but also randomness in information received, it is not straightforward to interpret the ensuing increase in utility from removing inattention. What I am interested in instead is the deviation from optimal consumption and labour choices which comes from the existence of inattention.

The average money-metric welfare loss across all inattentive agents was £1148. However, this headline figure masks some notable heterogeneity in how much people would benefit from the elimination of inattention, depending on their demographics. To examine this, I run an OLS regression of money-metric welfare losses on state variables in the first period for agents who start the model inattentive. The results are shown in Figure 19.

Figure 19: Money-metric welfare loss from having mistaken beliefs



The chart shows that the cohort that lost out the most from the imperfect communication of the reform is cohort 3, i.e. those who were born in 1951 or 1952 and thus turned 54 or 55 in 2006. Even though this cohort did not see the biggest increase in the SPA[21], they suffer the most from inattention because people in this cohort will become attentive closer to the SPA so will have to make more radical changes to their consumption and labour supply behaviour.

Unsurprisingly, more educated people benefit less from the elimination of inattention, because their higher wage means that it is easier for them to cover any unexpected shortfall in state pension income. Likewise, those with private pensions benefit less from the elimination of inattention due to the increased protection of a private pension.

It is somewhat surprising that couples benefit more from the elimination of inattention than singles do, insofar as couples have two income streams so are better protected against unexpected shocks to pension income. However, because there are two agents in a couple there is more scope to optimally adjust behaviour when attentive, which means that couples benefit (slightly) more from the elimination of inattention than singles do.

Finally, those people with more attachment to the labour force benefit less from the

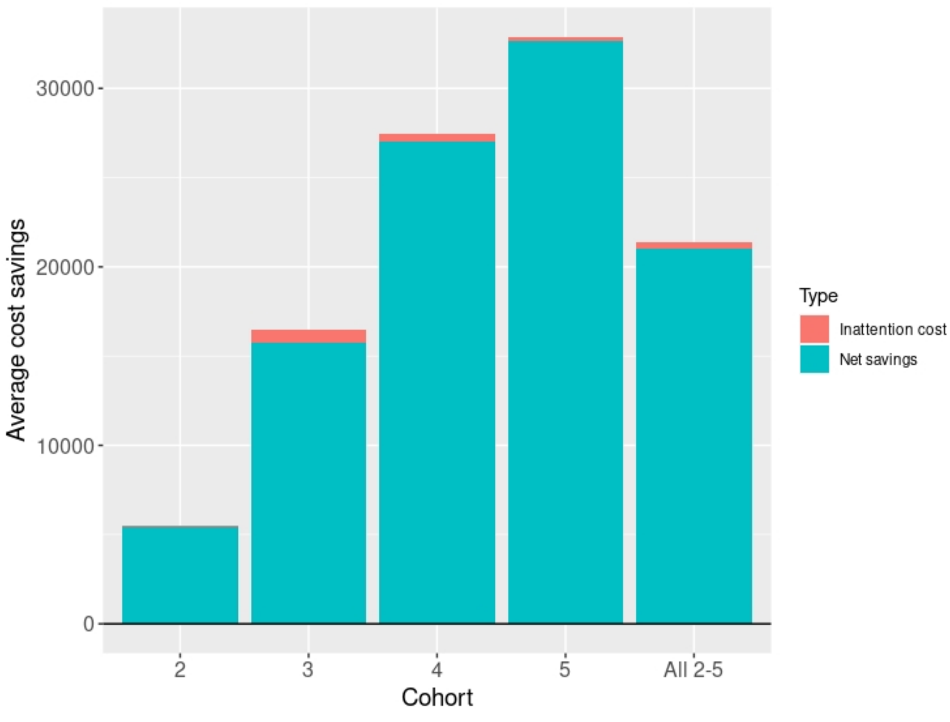
[21] In the model, their new SPA is 63, whereas for cohorts 4 and 5 the new SPA is 65 and 66 respectively

elimination of inattention. These people are better protected against shocks to state pension income as they can simply extend their stays in the labour force while keeping consumption relatively constant, whereas those who have already left the labour force may find it prohibitively costly to return and thus need to cut consumption to make ends meet.

5.3 How much of the cost savings were lost due to inattention?

Insofar as a motivation for pushing back people's SPA is cost savings, it is useful to consider how much the success of the cost savings was undermined by mistaken beliefs. To do this, I calculate the money-metric welfare loss from inattention, as in Section 5.2 above, and then subtract this from the cost savings per person from delaying pension payouts. This is then a measure of how much gross cost savings are lost once one takes into account the welfare loss of individuals. Figure 20 below shows the results of this exercise separately for different cohorts and for all cohorts 2-5 together[22].

Figure 20: Cost savings taking into account inattention



Even though there are notable costs of inattention these are much smaller than the overall cost savings that the reform achieved, so the net savings (i.e. gross savings minus average cost of inattention) are still very close to the gross savings. Even for cohort 3, with the largest costs associated with inattention, the costs of inattention are only 4.4% of the gross cost savings. This of course does not imply that the reform was necessarily welfare

[22]The reason why cohorts 0 and 1 are omitted is that these cohorts did not see a change in their SPA under the reform, and therefore there are no cost savings to be calculated.

improving, as that sort of calculation would need a reckoning of the costs to individuals of the reform as well as the benefits to the economy as a whole of incentivising people to work longer, but it is clear that the consumption equivalent of the loss in utility from inattention is only a small fraction of the gross savings of the reform.

6 Conclusion

In this paper I offer an assessment of the labour supply and welfare consequences of mistakes in retirement planning, exploiting data on agents' mistaken beliefs about the age at which they can receive their state pension. I find that agents with mistaken beliefs suffer an average cost of £1148 from having those mistaken beliefs, pointing to notable limitations in agents' ability to costlessly change their behaviour to correct their previous mistakes. The costs of mistaken beliefs are particularly high for those agents closest to retirement. Once agents realise their mistakes, they increase their labour supply to compensate for their loss of expected income. However, interpreting the SPA changes as a purely cost-cutting measure, the welfare loss to agents with mistaken beliefs does very little to offset the reduction in spending from the reform.

While the current paper has included several possible channels through which mistakes in retirement planning can be costly, such as utility and wage costs of re-entering the labour force having not worked in the previous period, or increasing disutility/decreasing wages of agents as they grow older, it has abstracted away from other important reasons why such mistakes are costly. Incorporating more sophisticated models of human capital depreciation, health and caring responsibilities, and non-separability in consumption and labour utility would allow a more in-depth assessment of the costs of mistakes in retirement planning, while allowing for non-unitary decisionmaking within the household would allow for study of who bears the burden of these mistakes. I leave these questions to future research.

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Appendices

A The UK state pension

A.1 Policy context

The state pension is a regular payment from the government which can be claimed by those above state pension age provided they have made or are credited with sufficient National Insurance (NI) contributions.

For those reaching SPA before 6 April 2016[23] , the relevant pension system was the "old" state pension (House of Commons Library 2024). This state pension had two tiers - the basic state pension (BSP) and the additional state pension. The basic state pension was a flat-rate benefit which people could build entitlement to by accruing NI qualifying years, i.e. years where they had either paid or been credited with NI contributions. On reaching the full number of qualifying years for the state pension, people qualified for the full state pension, otherwise they qualified for an amount proportional to their qualifying years.

The additional state pension had an earnings-related component. The exact nature of this component has varied over the decades, with the earnings-related component being introduced to the state pension system in 1961 and undergoing important reforms in 1978 and 2002. In particular, between 2002 and 2016, the relevant earnings-related component was the "second state pension", which gave extra payments to those on low and middle incomes (Royal London 2023).

For those reaching SPA after 6 April 2016, the relevant pension system was the "new" state pension (Department for Work and Pensions 2025b). A major objective of the reform was to increase clarity and transparency regarding pension entitlement by transforming it into a single-tier pension (Department for Work and Pensions 2013). Entitlement under the "new" state pension is generally based on NI contributions only, rather than having an earnings-related component (Department for Work and Pensions 2025b). For those people who built up entitlement under the pre-2016 system but had not received SPA in 2016, there were transitional arrangements in place under which their previous contributions would supplement the amount they were entitled to under the post-2016 system (Department for Work and Pensions 2013).

A.2 Imputing SPAs

In the public version of ELSA, respondents' months of birth are not made available. Instead, there is data on age (in years, at time of interview), year of birth, and month

[23]This would be women born before 6 April 1953 and men born before 6 April 1951.

and year of interview.

To impute month of birth, I calculate for each individual in the data the range of birth months it is possible for them to have, consistent with their age at the time of interview, the month and year of the interview and their year of birth. For instance, if someone is born in 1950 and is 59 years old when interviewed in October 2010, their birth month must be in October (later), November or December of 1950. If respondents are interviewed in different months across waves, more restrictions can be placed on the set of possible birth months. Then, I randomly assign each individual a birth month out of all the birth months which it would be possible for them to have.

Due to the fact that there will be errors in the imputed birth months, I choose a definition of correctness of beliefs in the main text (i.e. greater than 2 years out from the truth) that will avoid giving false positives for mistakes.

B Supplementary tables and figures

B.1 Estimation sample construction and descriptive statistics

To construct the estimation sample, I take the main ELSA sample and drop all those women born (strictly) before 1945 or after 1960, and who do not appear in Wave 3 (2006).

If an agent is missing data on their labour force status, I assume that they are in the labour force if they are below 60 for women, 65 for men, and otherwise assume they are not in the labour force.

If an agent is missing data on whether they are attentive or not (i.e. whether their SPA belief is more than 2 years out from the truth), I assume they are attentive.

I consider an agent to have a private pension if they are ever observed contributing to a private pension or receiving private pension income.

I winsorize income at the 5th and 95th percentiles.

Descriptive statistics on the estimation sample vs. the ELSA sample are presented in Table 3.

Table 3: Descriptive statistics

	Full ELSA sample	Estimation sample
Age	61.23	60.80
Married	0.70	0.70
Graduated HS	0.55	0.58
College	0.19	0.18
In FT work	0.38	0.38
Has priv. pen.	0.71	0.73
N	31132	10342

Notes - table displays means for each variable. Note that both samples comprise of women only.

B.2 Correlates of having correct beliefs

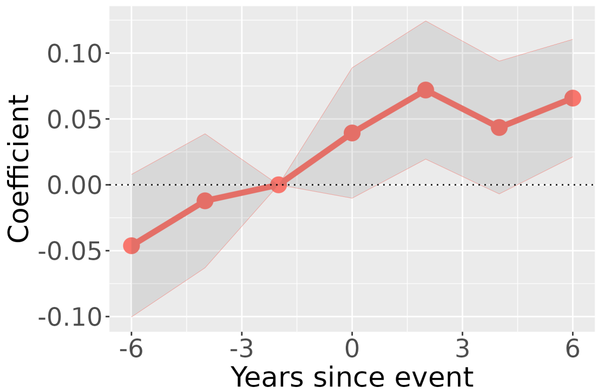
Table 4: Correlates of having correct beliefs

Dependent Variable:	Correct belief
High School	0.0063
	(0.0210)
College	-0.0122
	(0.0276)
Couple	-0.0657***
	(0.0199)
In labour force	0.0486***
	(0.0185)
Homeowner	0.0755***
	(0.0264)
Long-term planner	0.0625***
	(0.0188)
Socially isolated	-0.0229*
	(0.0138)
Financial resp.	-0.0038
	(0.0179)
Has private pension	0.0855***
	(0.0219)
Fixed-effects	
Age	Yes
YOB	Yes
Fit statistics	
Observations	2,885
R^2	0.15264
Within R^2	0.03215

Notes - standard errors clustered at individual level.

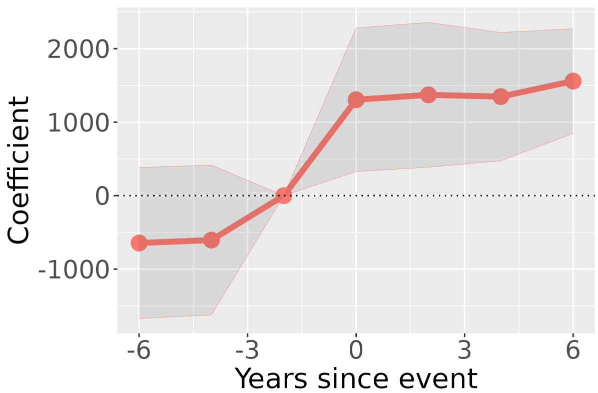
B.3 Event studies without differential age trends by initial labour force status

Figure 21: Event study (no differential age trend): labour force participation



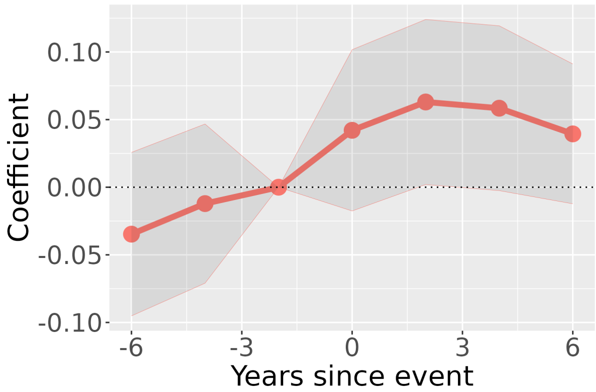
Notes: standard errors clustered at individual level.

Figure 22: Event study (no differential age trend): annual labour earnings



Notes: standard errors clustered at individual level.

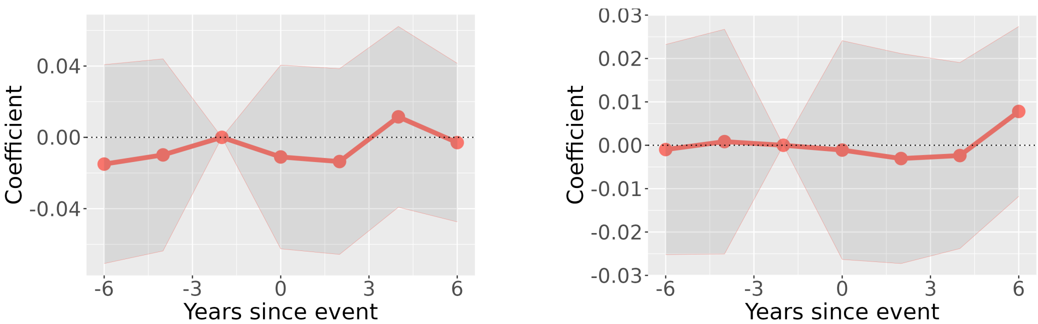
Figure 23: Event study (no differential age trend): spouse's labour force participation



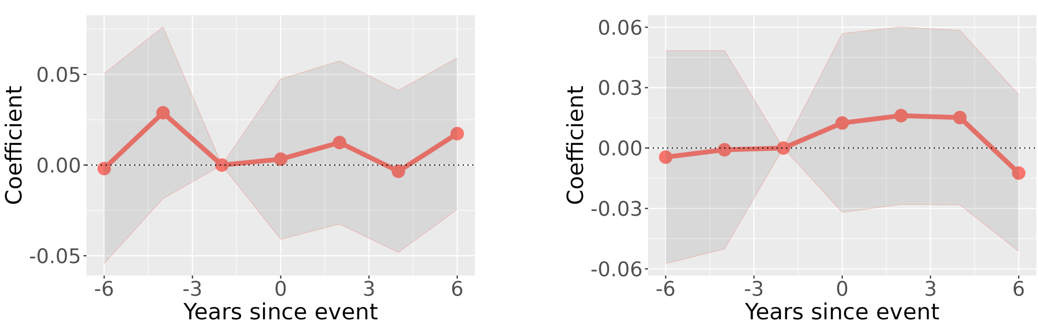
Notes: standard errors clustered at individual level.

Figure 24: Event studies: other outcome variables

(a) Log annual food spending (b) Own home



(c) >£10k financial wealth (d) Financially struggling



Notes - standard errors clustered at the individual level.