

Defined-contribution plans and retirement-financing behaviour in the United Kingdom

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Abstract

The aging global population has led to the increasing need for modern pension systems to ensure long-term financial security for citizens. In this study, we examine the impact of the adoption of the pension scheme auto-enrolment in 2012 on retirement financing behaviours in the United Kingdom. To conduct the empirical analysis, we utilize data from the 2018 cross-section second wave of the Financial Capability Survey. To address selection bias, a Heckman correction model is employed, and endogenous treatment regressions are used to account for endogeneity biases. The findings reveal that the implementation of auto-enrolment and defined-contribution (DC) pension plans has encouraged individuals to become more actively involved in pension contributions. Treated individuals are more inclined to diversify their retirement funds by investing in both liquid and illiquid assets. Additionally, positive effects are observed in retirement financing outcomes, which align with the life-cycle theory. Furthermore, the results of causal mediation analysis demonstrate that financial literacy and exposure to multiple financial information sources play a mediating role in the causal relationship between auto-enrolment and retirement finances, while retirement security and seeking professional advice have a moderating role.

Keywords: Financial literacy, Auto-Enrolment pension scheme, Defined contribution pensions, Retirement planning

JEL Classifications:

* Corresponding author, Northumbria University: Ioannis.Petrakis@northumbria.ac.uk. Georgios Panos: Aristotle University of Thessaloniki: gpanos@econ.auth.gr. The data for this study stems from the 2018 Financial Capability Survey, collected by the Money and Pensions Service. Neither the data collectors nor the Money and Pensions Service and its directors bear any responsibility for the findings, interpretations and conclusions of this study. Any remaining errors are our own.

1. Introduction

The increasing life expectancy of populations worldwide has raised concerns about the long-term sustainability of countries' pension systems. These concerns have been further amplified by the recurring economic crises. To address these challenges, many developed countries have adopted defined-contribution pension plans, aiming to encourage employees to take an active role in managing their retirement finances. Recent studies have shown that these plans have positive effects on employees' financial security, promoting greater engagement and literacy in pension management (Card and Ransom, 2011; Benartzi and Thaler, 2013; Mitchell and Utkus, 2022). In the United Kingdom, the newly introduced pension auto-enrolment scheme, first voted in 2012, marked a shift from defined-benefit (DB) to defined-contribution (DC) plans. Under this scheme, employees aged 22 and above, with an annual household income exceeding £10,000, are automatically enrolled in a workplace DC pension, where their employer also contributes a portion. Employees have the flexibility to choose their own contribution rates and can opt out or opt in at a later stage based on their individual preferences and needs. Moreover, they have the option to select the investment products for their pension pot and determine the level of risk they are comfortable with (Curry, 2008; Ring, 2012). These changes provide employees with greater control and choice over their pension investments.

Recent literature has discussed the impact of modern pension systems on financial outcomes in later stages of life. Lusardi, Michaud et al. (2017) suggest that financial knowledge can account for up to 35% of wealth inequality among older individuals. Therefore, pension systems that encourage active participation and demonstrate the ability to build retirement financial security are crucial throughout the life cycle. For our analysis, we utilize a cross-sectional sample of 4,082 individuals from the 2018 Financial Capability Survey, representing the four countries of the United Kingdom. Despite the country's relatively high level of financial development, concerns persist regarding retirement security and the sustainability of the pension system. These concerns led to the adoption of auto-enrolment as a policy measure, aiming to share the risk between employers and employees (Foster, 2018).

The Financial Capability Survey is one of the few representative surveys in the United Kingdom that provides a comprehensive set of indicators to examine the effects of the pension auto-enrolment scheme on retirement-financing behaviours. This dataset allows us to address several important questions, including: What are the advantages of auto-enrolment for retirement finances? Does participation in a defined-contribution (DC) plan lead to greater engagement in retirement financial matters? Do individuals rely solely on their pension, or do they have a desire to invest in other assets? What are the overall effects of DC plan participation on retirement finances? By analysing this dataset, we aim to shed light on the impacts of the pension auto-enrolment scheme on retirement financial behaviours and provide insights into the benefits and implications of participating in a DC pension plan.

As we delve into the examination of the relationship between auto-enrolment and retirement-financing behaviours, we encounter empirical challenges that need to be addressed. One such challenge is the fact that not all individuals choose to contribute to a pension plan, and some may opt to hold their savings outside the pension system. This highlights the need to account for selection bias to avoid making erroneous assumptions about the overall population. To address this first challenge, we employ the two-stage Heckman correction model, which helps mitigate potential selection bias. Additionally, the choice of a defined-contribution (DC) plan can introduce endogeneity issues based on omitted variables bias, necessitating the use of instrumental variables (IV) estimation. In our analysis, we utilize two representative and exogenous instruments for DC: whether the individual is a post-auto-enrolment scheme pension planner and their level of retirement literacy.

The empirical strategy follows a sequential decision-making logic, in modelling the process of decision-making regarding pension participation and retirement financing. We begin by examining the determinants of the decision to contribute to a pension plan, followed by the determinants of the choice of a defined-contribution plan. Subsequently, we explore the effects of defined-contributions plan participation on the decision to rely solely on pensions as retirement funds or to explore alternative investments. Finally, we investigate the effects on financial behaviours. By employing this analytical approach, we aim to provide a comprehensive understanding of the

complex relationship between auto-enrolment, retirement-financing decisions, and subsequent financial behaviours.

The findings of the study suggest that the implementation of auto-enrolment has positive effects on retirement planning. Not only does it encourage individuals to contribute to pension plans, particularly defined-contribution plans, but it also motivates them to actively invest in addition to relying solely on their pensions for their old age funds. In terms of retirement finances, auto-enrolment demonstrates positive effects on various aspects, including saving behaviours (measured through variables such as the logarithm of savings, savings-to-household income ratio, and saving specifically for old age), investment in liquid assets (such as stocks), and investment in illiquid assets (such as real estate). These results indicate that individuals who participate in DC plans are more likely to adopt optimal financial behaviours to secure their retirement. Furthermore, the study highlights the presence of regional differences in retirement planning and financial behaviours across the country. These regional disparities provide valuable insights into the diverse effects and outcomes of auto-enrolment on retirement finances among different geographical areas.

The causal mediation analysis in this study considers alternative variables that can potentially influence the causal relationship between defined-contribution plan participation and financial outcomes. Specifically, the analysis examines the mediating role of financial literacy and information exposure in this relationship, as well as the moderating roles of retirement security and professional advice for retirement planning and finances. The results indicate that financial literacy and information exposure play a significant mediating role in the relationship between defined-contribution plan participation and financial outcomes. These variables explain a considerable portion of the indirect effects observed. This finding highlights the importance of equipping individuals with financial knowledge and skills, as well as providing them with information from multiple sources, particularly in relation to the context of auto-enrolment. By developing these attributes, individuals are more likely to exhibit favourable behavioural responses and achieve better financial outcomes. Additionally, the study finds that retirement security and seeking professional advice have a moderating role in the relationship. These factors help to enhance and optimize the effects of defined-contribution plan participation on

financial outcomes. Their presence further underscores the importance of considering multiple factors and resources in the planning and decision-making process for retirement finances.

This paper consists of five sections. Following, *Section 2* offers a short literature review on the most recent studies on retirement planning and the Auto-Enrolment Scheme in the United Kingdom, while *Section 3* introduces the data and empirical strategy, including a descriptive analysis. *Section 4* presents the empirical results for the effects of the auto-enrolment scheme on retirement finances whereas *Section 5* presents the causal mediation analysis. *Section 6* presents the regional and lifecycle interaction effects while *Section 7* concludes.

2. Background and literature

The recent literature emphasizes the importance of retirement planning for achieving financial security, considering the global concerns surrounding the sustainability of retirement systems (Merton, 2014). Discussions have emerged regarding the effectiveness of various interventions in promoting pre-retirement engagement for planning and ensuring retirement security (Ekerdt, De Viney et al., 1996). Despite the prevalence of defined-benefit (DB) pension systems in both developed and developing countries, ongoing debates persist regarding their long-term sustainability and security. As a result, different policies are being explored to encourage employees to take a more active role in managing their pension funds (McGowan and Lunn, 2020). The transition to defined-contribution (DC) pensions aims to address these concerns by increasing employees' responsibilities in managing their retirement funds. This shift also provides individuals with additional options that can significantly influence their financial behaviour and savings patterns (Choi, 2015).

2.1 Pension auto-enrolment in the United Kingdom

The pension system in the United Kingdom has undergone significant changes over the past decade. Initially introduced with the Pensions Act in 2008 (Curry, 2008) and gradually implemented since 2012, employers are now required to automatically enrol their employees in workplace pension schemes, with individuals having the option to opt out or re-enrol at a later stage. This policy change aims to enhance the sustainability of pension funds and provide a reliable retirement income for the British

workforce. The aging population and the need to make non-state pension schemes more sustainable were key drivers behind these reforms, resulting in an increase in auto-enrolment from 31% of employees in 2012, when the legislation was first implemented, to 73% in 2016 as more employers adopted the changes (Foster, L., Wijeratne et al., 2021).

While the legislation has received criticism, particularly for excluding certain social groups such as carers, where women make up a significant portion (Foster, L., Wijeratne et al., 2021; Ginn and MacIntyre, 2013), there are several benefits associated with the new auto-enrolment pension schemes. It has been effective in promoting efficient pension saving behaviour and has led to an increase in average pension contribution rates due to the inclusion of newly enrolled employees (Cribb and Emmerson, 2016).

The transition to defined-contribution schemes (DC) have the potential to benefit pension savings, but it also requires trust and effective risk management. With DC pension schemes, employees can choose how their pension funds are invested and the potential returns, which comes with inherent risks. Both employers and employees need to have confidence in the new pension system and carefully consider their investment choices to mitigate potential risks (Ring, 2012). The behaviour of younger cohorts is a crucial factor to consider, as they often neglect saving for retirement at an early age. Foster (2017) conducted selective interviews to study the pension saving behaviour of younger employees and identified knowledge, advice, and myopia as important factors that influence their pension saving behaviour. In a subsequent study, Foster (2018) emphasized the benefits of "active aging" as a strategy to address future pension system challenges, promoting life-course retirement planning behaviours and active participation in society.

To conclude, the introduction of auto-enrolment pension schemes in the United Kingdom marked a significant policy change to transition from defined-benefit to defined-contribution pensions. The primary goal was to encourage a larger portion of the workforce to actively engage in making financial decisions through the pension system and establish a reliable retirement income. While the new system has faced criticism for excluding certain social groups, it has the potential to greatly benefit employees. However, it is important to recognize that the structure of defined-

contribution pensions also carries inherent risks. That triggered the research interest to examine its affects and leads to the first research hypothesis:

H₀: The exposure to the new pension system did not have any effects on retirement planning.

H₁: The exposure to the new pension system increased retirement planning and capability

2.2 Defined-contribution plans and planning for the long term

Following the discussion of pension system changes in the United Kingdom and the transition from defined-benefit (DB) to defined-contribution (DC) pension schemes, concerns arise regarding the potential risks and long-term implications of DC schemes on individuals' wealth dynamics. While financial literacy is considered essential for retirement planning and securing future income (Fornero and Monticone, 2011), there are also concerns about the exposure to risks associated with the stock market and its impact on pension funds. As Bernartzi and Thaler (2013) suggest, the aging population raises concerns about the future sustainability of pension systems, even in advanced economies such as the United States and the United Kingdom, due to employees' inertia in organizing their retirement plans. This is further highlighted by the fact that in 2010, nearly half of the US workforce (approximately 78 million individuals) did not participate in any pension plan.

Defined-contribution plans come into play to address and mitigate the lack of retirement planning, as they aim to encourage employees to engage in retirement planning and establish a savings behaviour for the future (Card and Ransom, 2011). Additionally, the combined contributions from employers and employees, as well as the option for individuals to determine the amount of income they wish to contribute to their pension pot above the minimum agreed rates, contribute to efforts to mitigate any existing risks. Meanwhile, the introduction of DC pension schemes and the increased involvement of individuals in retirement planning have generally had positive effects on their economic behaviour, as evidenced by the findings of Borsch-Supan, Bucher-Koenen et al. (2015) in the case of Germany. German households exposed to the new schemes actively engaged in their retirement planning, while it was observed that households with lower financial knowledge and education did not exhibit changes in terms of behaviour or retirement planning.

In addition to those findings, risk is another important factor to consider in DC plans, as the increased exposure of individuals to investment decision-making and new financial products can lead to higher volatility and less stable returns, as observed by [Sialm, Starks et al. \(2015\)](#) in the case of the United States. [Mitchell and Utkus \(2022\)](#), in a more recent study focusing on the United States, highlight the moderating role of fund managers in mitigating pension fund volatility and losses, given the significant growth of the corporate retirement plans market from 5 billion dollars in 2000 to 734 billion dollars in 2018. The adoption of more sophisticated investment strategies by pension fund managers in the United States has had positive effects on the stock market, resulting in higher equity values and returns, and offering the potential for a 50% increase in retirement plan values over a 30-year period.

In summary, the decision by the United Kingdom to implement auto-enrolled pension schemes represented a significant policy change aimed at creating a more sustainable and secure pension system, while also encouraging workers to actively engage in retirement planning and ensuring their income during retirement. Despite the criticisms and potential risks associated with DC pension plans, the benefits they offer seem to outweigh the risks and could play a crucial role in addressing the challenges posed by an ageing population and pension management.

3. Data and empirical strategy

This section describes the data used in the analysis and the empirical models used.

3.1 Descriptive statistics

We utilized the 2018 Financial Capability Survey, a cross-sectional survey that encompasses numerous indicators regarding the financial capability of adult individuals throughout the UK. The 2018 survey builds upon the 2015 wave and incorporates additional measures of capability. The sample consisted of 5,974 individuals of both working and retirement age. Weighting was applied to the data based on age, gender, and geographical region. Of the total sample, 4,668 individuals were of working age, while 1,306 individuals were aged 65 or above. The sampling process encompassed all geographical regions in the UK, enabling regional analysis for England, Scotland, Wales, and Northern Ireland.

Before examining the effects on retirement planning, six variables pertaining to retirement behaviour were identified. These variables encompassed aspects such as

whether individuals relied solely on their pension for retirement funds, whether their pension consisted solely of a state pension, and whether they engaged in additional investments alongside their pension plan or pursued alternative investment options. Furthermore, two variables were utilized to assess individuals' investment behaviour, differentiating between liquid assets (e.g., savings and retirement investments) and illiquid assets (e.g., downsizing intentions or investments in real estate for retirement purposes). Retirement financing outcomes were identified through five representative dependent variables. The first three variables pertained to saving behaviours and included the logarithm of the savings amount, the ratio of savings to annual household income, and a variable indicating saving for old age. Variables related to investing were determined by assessing stockholding behaviour and investments in real estate for retirement purposes.

For the analysis, we excluded individuals who were minors, aged 65 years or older, already retired, or economically inactive. Panel A in *Table 1* provides the summary statistics for the main demographic and other variables related to retirement planning, based on the pooled sample of 4,082 observations. Column 1 begins with the figures for the pooled sample of 4,082 individuals, with columns 2-5 following with the respective figures for defined-contributions (column 2), defined-benefits (column 3), both defined-contributions and defined-benefits (column 4) and no (column 5) pension participants respectively. Column 6 concludes with weighted t-test on differences of averages between defined-contributions (column 2) and defined-benefits (column 3) pension planners¹. The average age of the individuals is 39 years, with males accounting for 50.2% of the sample. Approximately 40.5% of the participants have either a university or vocational education, while 7.3% have no educational qualifications. Most of the sample is of white ethnicity (90.6%), and the participants are predominantly either single (41%) or married (49.8%). On average, they have around one child (0.71) and primarily reside in large cities (54.9%) or smaller cities (32.2%). A significant portion of the sample (41.9%) are homeowners with an outstanding mortgage, and the mean gross household income is £28,370. In terms of time orientation, the participants exhibit a medium level of present orientation. The majority are employees (71%), followed by self-employed

¹ The weighted t-test are computed with the *parmby* command in Stata 17 (Newson, 2008).

individuals (7.9%), with the unemployed representing the smallest proportion (4.9%). The most common country of residence is England (83.5%), followed by Scotland (8.7%), Wales (4.9%), and Northern Ireland (2.9%).

Turning to the differences in the sample based on pension plan participation, a minority of defined-contribution (DC) plan participants have primary qualifications (17%) or no qualifications (3.4%), compared to a higher share in the sample of defined-benefit (DB) plan participants (18.5% and 5.2% respectively). Moreover, single individuals are more likely to be DC planners (40.8% vs. 29.7%) and have an outstanding mortgage for their main residence (51.6% vs. 45.7%). DB planners are more likely to own their residence outright (25.5%). In terms of gross household income levels, DC participants show a superiority of £3,365, while they are marginally more likely to exhibit present-oriented behaviour. Differences in terms of labour status are also observed, as the sample of DC planners has a higher proportion of self-employed individuals (25.3%) and students (15.8%), compared to an increased share of employees (22.2%), unemployed individuals (20.3%), and homemakers (18.5%) in the sample of DB planners. On a regional perspective, marginal differences are observed, with more DB planners residing in Scotland, Wales, and Northern Ireland.

Moving to Panel B and the variables representing household financial outcomes, 30% of the pooled sample contribute to a defined-contribution (DC) plan, 25.1% to a defined-benefit (DB) plan, 8.2% to both a DC and a DB plan, while 36.7% do not own a plan at all. In terms of funding sources for retirement, 25.8% depend only on their pensions, while 14.7% rely on a state pension. 40.3% of individuals invest further for retirement purposes, with 35.5% investing in liquid assets and 15.3% investing in illiquid assets. A smaller portion (7.6%) relies on other types of funds for their retirement. Those participating in a DC plan are more likely to make additional investments (53.9%), whereas those participating in DB plans are more reliant on pensions (29.7%). Those without plan participation show the smallest shares.

The mean savings in the United Kingdom amount to £10,778, with DB planners having higher average savings compared to DC planners (a difference of £942), mainly due to their lower levels of investing. Consistent with that, they have a higher savings-to-income ratio (0.326 vs. 0.262). When it comes to saving for old age, 41.7% of the pooled sample do so, with 51.6% of DC planners doing so compared to 42.8% of DB

planners. Similar differences are observed in household finances, as 16.6% and 24.4% of DC planners invest in stocks or real estate respectively, whereas 13.4% and 19.8% of DB planners do so in comparison.

Regarding the attributes related to auto-enrolment, 31.8% of DC plan participants started contributing after 2012, compared to 22.8% of DB participants. There is a noticeable difference of 23.5% in terms of retirement literacy in favour of DC planners. On the other hand, DB participants have a higher retirement security score due to their pension status, but they have a lower average number of correct responses on financial literacy questions (a difference of 0.174). They are also less inclined to ask for retirement advice (a difference of 1.6%) and more inclined to ask for financial advice (a difference of 5.6%). The sample of defined-contribution planners shows a higher score on financial literacy (1.788) compared to defined-benefit planners (1.614) and the average number of planners (1.501). Finally, 40.2% of DC participants used more than one financial information source during the last year, compared to 37.6% of DB plan participants and 33.1% of the pooled sample average. *Appendix Table C1* offers a detailed description of the variables. *Appendix Table C2* shows the weighted pair-wise correlation matrix for selected key variables.

[Insert Table 1 about here]

3.2 *Empirical strategy*

The econometric approach follows a two-stage Heckman Correction model to treat for potential selection bias. To determine the effects of auto-enrolment on retirement financial behaviours, four distinct decisions/behaviours are considered.

The first decision relates to the sample selection and the two-stage Heckman model presented below. It considers whether individuals choose to contribute to a pension plan. Not all individuals wish to contribute to a pension pot, and the correction presented later aims to address any selection biases and make the econometric analysis representative of the population. This represents the first stage of the Heckman correction model. The second decision examines the probabilities of individuals opting in for a modern defined-contributions pension plan when they have already made the decision to contribute to a plan in general.

Moving deeper into retirement financing behaviours, the third decision examines individuals' longer-term retirement financial choices. Specifically, we explore the policy effects of auto-enrolment on retirement diversification strategies of individuals and whether they rely solely on their pension plans for retirement or intend to invest in additional assets. This leads to the fourth and final decision on the effects of DC plan participation on choices among liquid and illiquid assets.

The first two variables on liquid assets utilize the respective questions on the number of individuals' savings, along with an additional indicator measuring the ratio of savings to their annual income as an approximation of their saving rate. The variable for stock market participation is based on a question asking the participants where they hold their savings invested in the form of stocks. The final two indicators are based on a question asking about the expected funding sources in retirement. This leads to the respective variables for saving for old age and housing. The variable for housing refers to those who selected, in response to the question, that they hold real-estate investments for retirement or intend to downsize when the time comes.

The conceptualization is inclusive, as while on one hand we cover step-by-step the role of the policy on workers' retirement finances in the United Kingdom, we consider the same time the potential estimation biases that arise. Specifically, we start by treating for selection bias with a Heckman correction model, before we move on and address endogeneity biases arising from omitted variables and reverse causality.

Imagine we need to show the effects of auto-enrolment (x_1) on retirement planning (y_1). The Heckman style empirical model is of the form:

$$y_1^* = x_1' \times \beta_1 + x_3 \times \beta_3 + u_1 \quad (1)$$

$$y_2^* = x_2' \times \beta_2 + x_3 \times \beta_3 + u_2 \quad (2)$$

$$y_1 = y_1^* \quad \text{if } y_2^* > 0 \quad (3)$$

$$y_1 = 0 \quad \text{if } y_2^* \leq 0 \quad (4)$$

Model (2) describes a Probit model on the propensity to own a pension plan (y_2). In principle the variables y_1^* and y_2^* are not observed. The vector of variables in x_3 , utilized in both models, is a series of control variables in the specifications, with the

difference that in the baseline Heckman Probit Model (2) we define the exclusion criterion that employed or self-employed individuals would be expected to know whether they own a pension plan. The two stages in the correction model offers us the opportunity to comment on our findings as if they are population-representative. The error terms of the first and second stages are defined by u_2 and u_1 respectively.

Heckman (1979) proposed to estimate this two-stage limited-information maximum likelihood with the conditional expectation y_1^* of the subsample, (those who own a pension plan) being of the form:

$$E(y_1^* | x_1, y_2^* > 0) = x_1' \times \beta_1 + E(u_1 | u_2 > -x_2' \times \beta_2) \quad (5)$$

which under the assumption that the error terms follow a bivariate normal distribution the conditional expectation of the error terms is of the form:

$$E(u_1 | u_2 > -x_2' \times \beta_2) = \frac{\sigma_{12}}{\sigma_2} \times \frac{\varphi\left(-\left(x_2' \times \frac{\beta_2}{\sigma_2}\right)\right)}{1 - \Phi\left(-\left(x_2' \times \frac{\beta_2}{\sigma_2}\right)\right)} \quad (6)$$

where $\varphi(\cdot)$ and $\Phi(\cdot)$ represent the normal and cumulative normal densities of the standard normal distribution respectively. That means that the conditional expectation of y_1^* can be transformed to:

$$E(y_1^* | x_1, y_2^* > 0) = x_1 \times \beta_1 + \frac{\sigma_{12}}{\sigma_2} \times \frac{\varphi\left(-\left(x_2' \times \frac{\beta_2}{\sigma_2}\right)\right)}{1 - \Phi\left(-\left(x_2' \times \frac{\beta_2}{\sigma_2}\right)\right)} \quad (7)$$

Heckman (1979) proposed to keep from the first stage and the Probit estimation the inverse Mills ratio:

$$\lambda\left(x_2' \times \frac{\beta_2}{\sigma_2}\right) = \frac{\varphi\left(-\left(x_2' \times \frac{\beta_2}{\sigma_2}\right)\right)}{1 - \Phi\left(-\left(x_2' \times \frac{\beta_2}{\sigma_2}\right)\right)} \quad (8)$$

that corrects any selection bias in the second step. According to Heckman (1979), the selection bias is a special case of omitted variable bias.

Furthermore, for the analysis in the second stages in the correction model and upon treating for selection bias, we observe that λ might suffer from omitted variable

biases and reverse causality in the outcome models in the second stages starting from equation (9). To show unbiased and consistent estimates, we follow [Wooldridge \(2010\)](#) by estimating treatment linear regression estimations, with u_2 following a normal distribution and non-heteroskedastic error term.

The second stage of the Heckman correction follows endogenous treatment linear regressions as seen in [Wooldridge \(2010\)](#) and can be expressed through the equations set:

$$y_{0i} = x_i \times \beta_0 + \varepsilon_{0i} \quad (9)$$

$$y_{1i} = x_i \times \beta_{1i} + \varepsilon_{1i} \quad (10)$$

$$t = \begin{cases} 1, & \text{if } w_i \times \gamma + u_i > 0 \\ 0, & \text{otherwise} \end{cases} \quad (11)$$

where y_{0i} and y_{1i} represent the non-treatment and treatment outcomes for household finances outcomes and t representing the treatment under defined-contributions participation. The covariates x_i and w_i are uncorrelated to the error terms are uncorrelated and exogenous. We observe either of the outcomes and in specific dependent on treatment we observe the equation:

$$y_i = t_i \times y_{1i} + (1 - t_i) \times y_{0i} \quad (12)$$

The endogenous treatment linear regressions that represent the main econometric model in the analysis follow the instrumental variables (IV) method to treat for any remaining estimation bias. We select two instrumental variables in our analysis that satisfy the relevance and exogeneity criteria of IV.

The first instrumental variable is policy-related and is a dummy capturing whether the individual started contributing to a pension plan post the auto-enrolment legislation. Specifically, it refers to those pension planners who started contributing to a plan after 2012 and satisfy the age (older than 22 years old) and income criteria (more than £10,000) stipulated by the legislation. It is based on the respective question asking the participants the number of years they have contributed to their pension plan. The second instrument is retirement literacy and is based on two relevant questions asking the participants whether they understand the differences between defined-contributions and defined-benefits pension plans. Both instruments are statistically

significantly predicting the endogenous variables (choosing a DC plan), and are exogenous to our selection of outcomes in decisions 3 and 4 on retirement finances, as we cannot state that participants should not be affected either on diversifying their pension pots, or the products of their preference from either when did they start building their pot -an thus be exposed to the new law- or their retirement literacy on choosing among DB and DC plans.

The last stage of the empirical analysis concludes with causal mediation analysis, following the models from [Dippel et al. \(2022\)](#) and improving our understanding of confounding variables affecting the policy effect on retirement finances. The mediation models include a treatment variable T (DC), a selection of final outcomes Y related to retirement finances and asset holding and a selection of mediating variables M (financial literacy, retirement security, asking for retirement and financial advice, and information exposure). The mediating variables M represent the mechanism through which the treatment variable T affects the outcome variables Y.

The mediating variable, M, is indeed causally impacted by T, and mediates part of the overall causal effect of T on Y. The model differentiates the “*total effect*” into “*direct effect*” and “*indirect effect*” of T on Y through M. Hence, we employ an instrumental variable Z, which could be added to cope with the endogeneity of both T and M.

To facilitate those causal relationships examined in the partially confounded instrumental variables causal mediation model, we capture the direct effect ($DE = \beta^T_Y$) of T on Y, independent of M. Then, we estimate the indirect effect by multiplying the coefficients of M and Y by those of Y ($IE = u^T_M * \beta^M_Y$). The total effect consists of the sum of the two terms ($TE = \eta^T_Y + \eta^T_M * \beta^M_Y$). The model specifications are of the form:

$$Z = \varepsilon_Z \quad (13)$$

$$T = \beta^Z_T \times Z + \varepsilon_T \quad (14)$$

$$M = u^T_M \times T + \varepsilon_M \quad (15)$$

$$Y = \eta_Y^T \times T + \eta_Y^M \times M + \varepsilon_Y \quad (16)$$

The causal mediation analysis follows three model estimations: first we estimate the causal effect of T on M (15). Then, we estimate the causal effect of T on Y². The last stage of the model as in equation (16) considers the three types of total, indirect and direct effects explained before:

$$M = f_M(T, \varepsilon_M) \quad (17)$$

$$Y = f_Y(T, M, \varepsilon_Y) \quad (18)$$

The relationships presented in equations (17) and (18) that characterize the causal mediation equation show the effect of T through M directly and indirectly causing Y. Hence, in the regression of Y on T and M, there are two potentially endogenous variables, but only one instrumental variables, Z, addresses their endogeneity. *Appendix Figure 1* offers a visualization of the partially confounded instrumental variables causal mediation model as in [Dippel et al. \(2022\)](#), adjusted in our study needs.

[Insert Figure 1 about here]

4. The effects of defined-contributions plan participation on retirement finances

We start by estimating the first stages of the correction model as in equations (1)-(8). To facilitate understanding of the linear effects magnitude, we divide the coefficient estimates with the model's linear probability. The regressions are weighted at the population level.

4.1 Pension plan participation

In *Table 2*, columns A₀ and A₁ present the estimates from linear probability models on pension plan participation, for the first stage of the Heckman model as in equation (5). Column A₀ includes only the exclusion criterion -being an employee-. Column A₁

² We characterising as estimating causal relationships, as in both cases we estimate instrumental variables IV models to treat for endogeneity bias in T and including the excluding instrumental variables Z (14).

adds the two instruments used in the endogenous treatment regressions in the second stages of the Heckman model.

The estimation results in column A₀ indicate that employees are 42.1% more likely to participate in a pension plan, statistically significant at 1%. When we include the instrumental variables in column A₁ following, employees continue to be more likely to contribute to a plan by 38.9%, while those who started contributing after the auto-enrolment policy are 17.5% more likely to do so at 1% significance.

In column B₁, we estimate the marginal effects from a Probit model using the same regression specifications as in column A₁. This follows equations (6)-(8), where we then estimate the inverse mills ratio to be utilized for the second stages and treat for selection. The marginal effects estimates indicate that employees are 36.2% more likely to contribute to a pension plan at a significance level of 1%. If they are entrants post-auto-enrolment, they are 17.1% more likely to contribute, and if they are retirement literate, they are 21.9% more likely to contribute.

On the determinants of the profile of pension planner, old-age participants are 1.3% more likely to have a pension, while those who are more present oriented are 1.8% less likely to have a pension. Education is a strong predictor for participation, with individuals who have higher levels of educational attainment being more likely to contribute to a pension compared to those without any, while the likelihood increases among higher education levels. Widowed or divorced individuals are 10.5% more likely to possess a pension at a significance level of 10% compared to married ones. Furthermore, individuals who own their main residence with an outstanding mortgage are 13.3% more likely to plan their pension compared to those who do not own their home and are renting. Living in a large city decreases the likelihood of pension plan participation by 7.2% at 10% compared to living in a small city or suburbs. The remaining controls do not exert significant effects.

The remaining columns C₁-C₃ conduct a robustness exercise, where we estimate a multinomial Probit model *without* Heckman correction to support our findings. The categorical dependent variable on pension choice has a base category (as in column C₃) of not contributing to a pension, while the other categories include contributing to a plan or being uncertain about plan participation. The estimated marginal effects

indicate that individuals who started contributing to a pension after the auto-enrolment scheme are 20.1% more likely to consistently contribute to a pension, 13.1% less likely to be uncertain about their plan participation, and 27.4% less likely to not contribute to a pension or opt out. These estimates are statistically significant at a significance level of 1%. Furthermore, the second instrument for retirement literacy also has statistically significant effects. Retirement literate individuals are 23.3% more likely to participate in a pension plan, 74.4% less likely to be uncertain about their plan participation, and 19.6% less likely to not participate in a pension.

[Insert Table 2 about here]

4.2 *Defined-contributions plan participation*

We did treat for selection in *Table 2*, securing unbiased and consistent estimates for the second stages. Follow in *Table 3*, we examine the effects of auto-enrolment (the policy) on whether the plan of choice is a defined-contributions (DC) modern pension. Columns A₁, B₁, and C₁ present the marginal effects from Probit regressions, which can serve as the first stages for the endogenous treatment maximum likelihood regressions for treating for endogeneity. Columns A₁ and B₁ include the two instruments separately, while column C₁ includes both instruments in the same specification.

The results indicate that individuals who started participating in a pension plan after 2012 are 69.2% more likely to contribute to a defined-contributions plan at a significance level of 1%, as shown in column A₁. Furthermore, the likelihood increases to 95.4% for retirement literate individuals, as seen in column B₁. In column C₁, both instruments have significant effects close in magnitudes. Entrants post-auto-enrolment are 66.1% more likely to have a defined-contributions pension plan, and retirement literate individuals are 95% more likely. The inverse Mills ratio is included in every specification, as the specifications in question as representative of the second stages of the Heckman.

The remaining four columns in D₁-D₄, continue the robustness exercise by estimating a multinomial Probit model without considering selection. The dependent variable represents a categorical variable indicating whether the pension is defined-contributions, defined-benefits, a mix of them, or if the individual does not have a pension to contribute to at all. The marginal effects obtained from this model align

with those under the Heckman correction and demonstrate a noticeable decrease for the case of defined-contributions plans. This confirms the presence of selection bias.

The model in columns D₁-D₄, we disseminate the marginal effects by type of pension. Entrants post-auto-enrolment are 11.8% more likely to contribute to a defined-contributions plan compared to a defined-benefits plan, indicating a preference for defined-contributions plans. This preference is further supported by the negative effect for mixed pensions in column D₃. Additionally, auto-enrolment decreases the likelihood of not planning for retirement by 26.1%. The estimates related to retirement literacy follow similar trends. Literate planners are 27.8% more likely to own a defined-contributions plan and 9.2% less likely to own a defined-benefits plan³.

[Insert Table 3 about here]

4.3 Defined-contributions pension plans and retirement finances in the United Kingdom

We can now delve to the role of the policy and choosing a defined-contributions plan on retirement finances. As explained in the empirical strategy, the first decision-making stage is whether the pension planners prefer to build upon their pension pots. The second decision focuses on which relevant financial products they choose. Both regression specification follows those as in equation (12).

4.3.1 The determinants of retirement finances in the United Kingdom

We create six (6) outcomes that capture how individuals assess their retirement finances in the long-term. In column 1, we present the effects for those who rely solely on their pensions (whether they are state pensions or personal/workplace pensions) for the old age. Column 2 continues with those who rely solely only on a state pension, while column 3 shows the effects on those have available funds besides their pension pots. Column 4 presents the estimates for those who choose to invest beyond their plans, while columns 5- 6 conclude with the effects on choosing to invest in liquid or illiquid assets.

³ At this stage, it is important to remind that the auto-enrolment policy did not result in an automatic transition of all workplace pensions to defined-contributions plans instantly, rather than a gradual shift over time until 2018.

Contributing to a DC plan, in column 1, does not exert significantly affect the choice to rely solely on a pension pot for the old age. However, treated individuals are 140% less likely to rely solely on a state pension in column 2. This is an expected outcome, as defined-contributions plans are personal/workplace plans. The remaining specifications provide further insights into the decision-making of those under treatment. In column 3 we see that investing in other type of assets besides a pension fund does not exert significant effects.

The estimates in column 4 show that DC planners are 84.9% more likely to invest further rather than relying solely on their pension funds. This suggests that auto-enrolment has made planners more active and willing to take control of their retirement finances. Additionally, they are 95% more likely to invest in liquid assets (column 5), and 104.7% more likely to invest in illiquid assets (column 6).

The new policy seems to trigger on retirement finance planning among the treated group.

[Insert Table 4 about here]

4.3.2 Pension plan participation and household financial behaviour

In *Table 5*, we conclude with the effects on retirement finances asset preferences. Five indicators are selected to assess the impact on saving and investing behaviours. The first is the logarithm of savings, followed by a variable measuring the savings-to-income ratio. We complement saving with a binary dummy on whether their purpose of saving is for the old age. Shifting to investing, we examine the policy effects on investing in liquid assets through stock market participation with stock ownership. The impact on investing in illiquid assets is assessed through ownership of real estate for the old ages.

Defined-contribution planners exhibit positive effects on savings in column 1, as they are 34.2% more likely to own increasing savings amount. They are also 73.2% more likely to show a higher savings-to-income ratio. Additionally, they are 70.1% more likely the purpose of saving to be for old age. These estimates are statistically significant at the 1% level for the first two specifications and at the 5% level for saving for old age. The policy itself and especially the choice of a modern plan induces saving behaviours.

Moving to investing in columns 5-6 at 5% significance, the treated group are more inclined to invest further, as owners of defined-contribution plans are 108.3% more likely to participate in the stock market with the form of stock ownership. This signifies a proactive approach to control their finances and boost their financial well-being. Furthermore, these planners are 88.6% more likely to be owners of other real estate, which serves as a safer asset choice .

Overall, *Tables 4 and 5* provide conclusive insights into the benefits of the modern pension system adaptation in the United Kingdom. The findings suggest that this system not only encourages the treated workers to be proactive and diversify their old ages finances beyond their pension pots, but also promotes efficient retirement finances behaviours encouraging saving and investing.

The findings align with the policy expectations. Policymakers aimed to improve the long-term sustainability of the pension by stimulating planners to control their retirement finances. Robustness specifications estimates can be found in Appendix Table 4, where we follow the same robustness exercise with estimating specifications without Heckman correction.

[Insert Table 5 about here]

4.3.3 Pension plan participation and retirement finances over regions and the life-cycle

The empirical analysis conducted thus far has yielded interesting conclusions regarding how auto-enrolment has contributed to sustainable retirement finances and improved outcomes for individuals. In the final part of *Section 4*, we explore regional and life-cycle differences in terms of retirement finance outcomes. These findings will provide further insights into how the new pension system has been adopted across different government regions in the country. Additionally, it establishes a theoretical link to the traditional life-cycle theory, which suggests that younger individuals tend to invest more to enjoy the returns during their later years or retirement.

Figure 2 presents the estimates obtained from separate regression specifications with the inclusion of an interaction term between the defined-contributions plan and each British government region. The outcomes are the three respective variables on saving behaviours: the logarithm of savings, the ratio of savings to income, and saving

for old age. The findings indicate that residents in Scotland, Wales, and West Midlands who are treated and under an auto-enrolment plan are more likely to have higher savings, and these results are statistically significant. However, the remaining estimates are not significant, with the interaction term for London being marginally statistically insignificant. It is worth noting that London, being the largest city and the capital, represents a higher share of the population.

In terms of signs of the coefficients, the interactions for residents of Yorkshire and the Humber and North East with defined-contributions plans are negative. The interactions for the savings to income ratio are not significant. Following, the interactions related to saving for old age provide more informative results. Participants in defined-contributions plans in East Midlands, North West, and South West show the highest estimates for saving for old age, and significant interactions can also be observed for residents in Scotland, Wales, and London. It is interesting to note that all the results for saving for old age are positive, indicating that defined-contributions plans encourage saving for later stages of life across all regions.

[Insert Figure 2 about here]

Figure 3 displays the interaction terms between defined-contributions plan participation and region for the investing outcomes. The results indicate that treated residents of London and Wales are more likely to invest in stocks. The remaining regions show positive effects, although they are not statistically significant. However, the significant interaction term for London is particularly noteworthy, as the city serves as a major financial market in Europe, suggesting that residents in London have increased exposure to liquid investments and the stock market. When examining the interaction terms for real estate investments, participants with defined-contributions plans residing in South East, Northern Ireland, and London display significant interactions in sequence. Specifically, London residents with defined-contributions plans are more likely to invest in both stocks and real estate for retirement. While Northern Ireland residents do not show significant interactions for stockholding, they do exhibit significant interaction effects for real estate, indicating a preference for less risky investments. This preference for less risky investments is also observed among residents in the South East region.

[Insert Figure 3 about here]

The remaining two figures examine the life-cycle effects of auto-enrolment. To analyse the life-cycle considerations, three age groups are created: one group for individuals aged 18-34 representing the young cohorts, another group for individuals aged 35-50, and a third group for individuals aged 51-64 representing the older and closer-to-retirement cohorts. These two figures, *Figure 4* and *Figure 5*, present the effects of these age groups on retirement finances outcomes, like the previous figures that focused on regional differences.

As observed in *Figure 4*, the interaction effects of the age groups 18-34 (younger) and 51-64 (older) on the logarithm of savings are comparable in magnitude. However, it is noteworthy that the effects for the age group 18-34 are statistically significant, indicating that younger individuals with defined-contributions plans save more at an earlier stage in life. Additionally, the interaction effects on saving for old age provide further insights, highlighting the differences in effects across age groups. The age group 18-34 is significantly more likely to save for old age by 0.15 percentage points, whereas the age groups 35-50 and 51-64 are more likely to do so by 0.10 percentage points. This represents a 50% higher probability for the younger cohorts, which aligns with the theoretical life-cycle model of saving behaviours, suggesting that people tend to save and invest earlier in their working life so that they can enjoy the fruits of their behaviours and accumulate wealth closer to retirement.

[Insert Figure 4 about here]

The interaction effects between age and defined-contributions plans in *Figure 5* provide conclusive findings on investing behaviours. The estimates further support the life-cycle hypothesis, particularly for the 18-34 age cohort, which exhibits statistically significant effects. This younger cohort is significantly more likely to invest in stocks and real estate by 0.06 and 0.09 percentage points, respectively. The age group of 35-50 also shows a significant effect, with a 0.04 percentage point increase in the likelihood of investing in stocks. In contrast, the interaction effects for the older cohort of 51-64 are smaller in magnitude and non-significant, indicating that they are less inclined to invest in both liquid and illiquid assets. This pattern suggests that younger individuals with defined-contributions plans are more active in investing, while older

individuals may benefit from their earlier investments made during their younger years.

Overall, regional differences exist in the United Kingdom, and the impact of auto-enrolment varies across regions. However, auto-enrolment has induced efficient behaviours nationwide. Furthermore, the analysis reveals that auto-enrolment has made younger age groups more proactive and enthusiastic about saving and investing to build their retirement capability. On the other hand, individuals aged 50 and older, who are closer to retirement, are more inclined to accumulate their wealth rather than save or invest further.

[Insert Figure 5 about here]

5. Causal mediation analysis

The exposure to auto-enrolment has shown positive effects on household financial behaviour. However, it is essential to explore whether there are confounding factors in the policy effects. In this section, we consider five additional variables that could potentially act as mediators on retirement financing outcomes, in addition to defined-contributions plan participation. To examine the potential mediating role of these variables, we utilize instrumental variables (IV) causal mediation analysis, as proposed in the partially confounded causal mediation model by [Dippel, Gold et al. \(2022\)](#). This methodology allows for the decomposition of the total effect into a direct effect and an indirect effect, providing insights into how much of the total effect is explained by the mediating variable's indirect effect as explained before.

The five variables considered in this analysis are financial literacy, retirement security, asking for retirement and financial advice, and information exposure. Financial literacy is measured based on individuals' correct responses to questions related to inflation, interest, and compound interest. Retirement security is a composite variable created using principal components analysis from variables related to retirement finances preparation and individuals' time expectations. Retirement advice represents individuals who sought specialized professional advice for retirement planning, while financial advice refers to those who sought general advice on finances. Lastly, information exposure measures the percentage of individuals who utilized more than one financial information source during the last year.

All regression models follow the specifications of the causal mediation model as presented in equations (13)-(18).

5.1 *The mediating role of financial literacy*

Financial literacy has emerged as a significant area of research within household finance, and the number of studies on this topic has increased in recent years, partly due to the availability of survey data in the United Kingdom. While in the beginning it was addressed as cognition skills, numeracy and their role on retirement planning (Banks et al., 2010; Smith et al., 2010), following studies utilize the propositions on defining financial literacy by Lusardi (2008) to examine its role on household long-term finances.

Recent studies examine the role of financial literacy with indebtedness in the United Kingdom (Gathergood and Disney, 2011; Gathergood, 2012), finding positive spillovers and highlighting its role on sustainable household finances and portfolios performance. However, they do also highlight potential negative spillovers through lack of self-control and increasing probability of exposure to financial risks and income shocks (Gathergood, 2012). It is evident, though, that users of consumer credit in the United Kingdom tend to have lower financial literacy levels (Disney and Gathergood, 2013) and not being confident on their understanding of credit.

Cultural disparities (Nicolini et al., 2013) can also explain financial literacy gaps among countries, while literate citizens in the country show preference for centre political parties (Montagnoli et al., 2016; 2017). They also tend to disapprove government interventions with redistributive policies.

At the firm level, it is shown that financial literacy is a significant skill that mitigates potential information asymmetries and improves access to finance and financial management for SMEs (Hussain et al., 2018), while finally recent literature documents a gender gap in retirement planning, with women being less likely to plan for the old age compared to men (Farrar et al., 2019), but financial literacy not being among significant factors tackling this disparity.

5.2 The roles of information exposure, retirement security, and professional advice

Other factors that could affect policy implementation and retirement finances is professional advice, recently documented as a noticeable tool for efficient policy implementation and contributing to understanding of policy terms (Bodie, 2003 ;Seay et al., 2016; Anderson et al., 2017; Ryan, 2021). It is shown that financial advice can significantly induce retirement planning and enhance retirement fund management (Chatterjee and Fan, 2023), while professional advisors can optimize old age planning and achieving long-term financial goals of planners (Marsden et al., 2011).

Complementing this, exposure to information is also important, as it contributes to policy knowledge (Duflo and Saez, 2003) and can be addressed through different platforms, as e.g. either on directly informing employees in the workplace (Collins and Urban, 2016) or utilizing technology for personalised information exposure (Hoffmann and Plotkina, 2020).

5.3 Causal mediation analysis results

Table 6 presents the estimates from the instrumental variables' causal mediation analysis, organized into five panels corresponding to each of the mediating variables considered. Panel A presents the results for financial literacy, followed by panel B for information exposure, and panel C for retirement security. Panels D and E conclude with the causal mediation analysis involving retirement and financial advice as mediators⁴⁵.

Panel A in Table 6 presents the results for financial literacy. The estimates indicate that financial literacy plays a *mediating* role in the relationship between defined-contributions plans and retirement financing, except for saving for old age in column A3, where financial literacy has a *moderating* role and enhances the effect. The indirect effect mediated by financial literacy explains a substantial portion of the total effect on the logarithm of savings (95.7%) and savings to income ratio (95.4%) for the saving behaviour indicators. Additionally, the indirect effect also explains a

⁴ The moderating role of those variables is also considered, determined by the causal mediation analysis results.

⁵ The mediating role is seen when the mediator “*absorbs*” the statistical significance from the variable for defined-contributions, whereas the moderating role is defined when they both show statistically significant effects.

significant portion but maintains a moderating role on saving for old age (72.5%). Given that financial literacy primarily influences financial decisions, the findings related to investing behaviours in columns A₄ and A₅ are noteworthy. The indirect effects mediated by financial literacy account for 87.5% of the total effect on stockholding and 87.9% of the total effect on real estate investments.

Moving to panel B, focusing on information exposure, we find that it is a mediating variable in all the specifications except for saving for old age, where it does not have any effect on the causal relationship. However, the indirect effect of information exposure is noteworthy. It explains 101.1% of the total effect on the logarithm of savings, 101.9% on savings to income ratio, 89.1% on stockholding, and 90.7% on real estate investments. This highlights the importance of being exposed to information, in addition to being enrolled in auto-enrolment and contributing to defined-contributions plans, in influencing retirement financing outcomes.

The remaining estimates in panels C, D, and E of the causal mediation analysis pertain to the indirect effects of retirement security, retirement, and financial advice, respectively. We observe that all three variables play a moderating role in most of the specifications and contribute to increasing the total effect of defined-contributions plans on household financial behaviours, as presented in *Table 5*. However, it is important to note that these variables *do not fully explain* the causal relationship, as there are other factors at play. Nevertheless, the moderation effects are substantial, ranging from at least 70% in all cases, indicating that they can have a significant impact and be beneficial for individuals with defined-contributions plans.

The causal mediation analysis yields intriguing findings regarding the impact of other factors on the policy effects on retirement finances. While retirement security and access to professional advice can enhance the effectiveness of outcomes, it is financial literacy and information exposure that play a mediating role. This implies that policymakers should prioritize efforts to enhance individuals' financial knowledge and provide them with more relevant and comprehensive information. These measures will create favorable conditions for individuals to explore additional retirement financing options beyond their pensions. While auto-enrolment promotes optimal financial behaviours, it is equally important to focus on improving people's skills and knowledge in the process.

[Insert Table 6 about here]

6. Concluding remarks

The importance of having sustainable and efficient pension systems has been widely discussed in the economics literature. Recent studies emphasize the need to modernize pensions and provide opportunities for individuals to enhance their knowledge and skills (Lusardi and Mitchell, 2011). This study takes advantage of the reforms in the United Kingdom's pension system in 2012, and the introduction of auto-enrolment and defined-contributions plans, to examine how this policy change has influenced retirement financing behaviours in the country.

To address selection bias and endogeneity, the empirical strategy employs a robust approach, utilizing a Heckman correction model for selection bias and instrumental variables treatment linear regressions for endogeneity. It also utilizes the rich in information data from the 2018 Financial Capability Survey for the empirical analysis.

We begin by examining the effects of auto-enrolment on pension plan participation, as it is important to ensure that the findings are representative of the population, considering that not all employees contribute to a pension. Additionally, a structural analysis is conducted to understand how auto-enrolment has impacted retirement behaviours. The estimates demonstrate that auto-enrolment has increased individuals' inclination to contribute to a pension and has had a positive effect on retirement planning in general. Furthermore, since the new scheme has also favoured modern defined-contribution plans, the analysis continues by investigating the effects on defined-contributions plan participation. The results confirm that auto-enrolment has influenced individuals to invest in modern (DC) pensions rather than traditional defined-benefit plans. Taking both sets of findings into consideration, it can be concluded that policymakers have successfully encouraged previously excluded individuals to engage in pension planning and have attracted them to pension plans that, at least in theory, enable them to be more proactive and take responsibility for their retirement finances.

The subsequent stage of the empirical analysis builds on this argument and investigates the impact of participating in defined-contributions plans on retirement financial behaviours. Specifically, it examines whether individuals who participate in

such plans rely solely on their pension pots or whether the availability of these new plans encourages them to explore alternative options outside the pension system.

The results of this analysis provide valuable insights. It is observed that individuals who are enrolled in auto-enrolment and own defined-contributions pension plans are more inclined to diversify their retirement finances and invest in additional liquid and illiquid assets, rather than solely relying on their pensions. The second stage of the analysis focuses on the outcomes of retirement finances and explores how auto-enrolment has affected saving and investing behaviours. The subsequent estimates reveal that individuals who have been subject to the auto-enrolment policy are more likely to save, as evidenced by the higher amount of savings and the ratio of saving to income. Additionally, these individuals are more inclined to save specifically for old age and to invest in stocks (representative of liquid assets) as well as other real estate for retirement purposes (representative of illiquid assets).

The empirical results demonstrate a clear pattern illustrating how auto-enrolment has influenced retirement financial behaviours in the United Kingdom. In summary, the findings indicate that auto-enrolment has had a positive impact on retirement planning, as evidenced by increased pension plan participation. Furthermore, it has led to a notable shift towards defined-contributions plans. Under the auto-enrolment scheme, individuals who participate in defined-contributions plans are more inclined to explore additional investment options beyond their pensions, indicating a desire for diversification. These individuals also exhibit more efficient household financial behaviours. The advantages of the new pension system are manifold, and in the long term, it has the potential to foster sustainable retirement financial behaviours and outcomes.

Finally, the analysis also considers regional and life-cycle factors. Regional disparities within the United Kingdom are evident, with London exhibiting the most significant interaction effects compared to other government regions across all specifications. Auto-enrolment has not only had a positive impact on England but also on Scotland, Wales, and Northern Ireland, as indicated by the respective specifications. The second part of the analysis focuses on the life-cycle implications of auto-enrolment. This aspect is particularly insightful for policymakers as it sheds light on which age cohorts have been most affected by the policy change and whether it has had a long-term effectiveness. The estimates confirm the traditional life-cycle

model, with the youngest age cohort (18-34 years old) experiencing the most significant positive effects on retirement financing outcomes due to auto-enrolment.

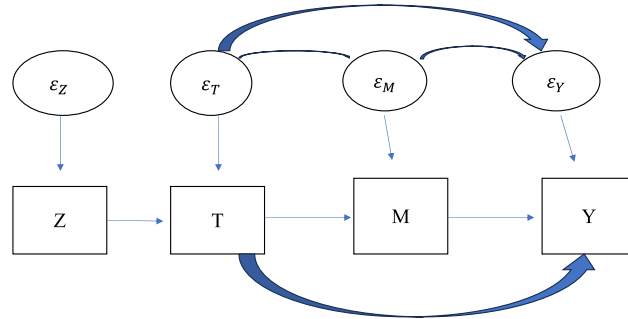
Finally, we go beyond these effects and explore alternative mediating variables using causal mediation analysis. The results reveal that financial literacy and exposure to multiple financial information sources effectively account for the largest portion of the total effect of defined-contribution plans on retirement financing outcomes. This finding contributes to the ongoing debate on how to enhance policymaking by emphasizing the importance of developing financial knowledge and information skills among planners, thereby maximizing the benefits derived from the new policy.

Additionally, while retirement security and the availability of professional advice (both retirement and financial) also play a role in the relationship, they are unable to fully explain it. These results highlight the significance of financial literacy and information exposure, suggesting that policymakers should prioritize efforts to improve individuals' financial knowledge and information skills to optimize the outcomes of the new policy. Moreover, ensuring retirement security and promoting access to professional advice can further contribute to the overall relationship between defined-contribution plans and retirement financing outcomes.

This study makes a valuable contribution to the recent literature discussing retirement planning and financial behaviours. The rigorous empirical approach employed results in robust and reliable findings. Furthermore, we provide valuable insights for policymakers, not only we demonstrate the positive impact of auto-enrolment on retirement financing behaviours, encouraging active participation in retirement planning, but also discuss factor that mediate the policy effects.

Figure 1

Graphical presentation, Causal mediation analysis



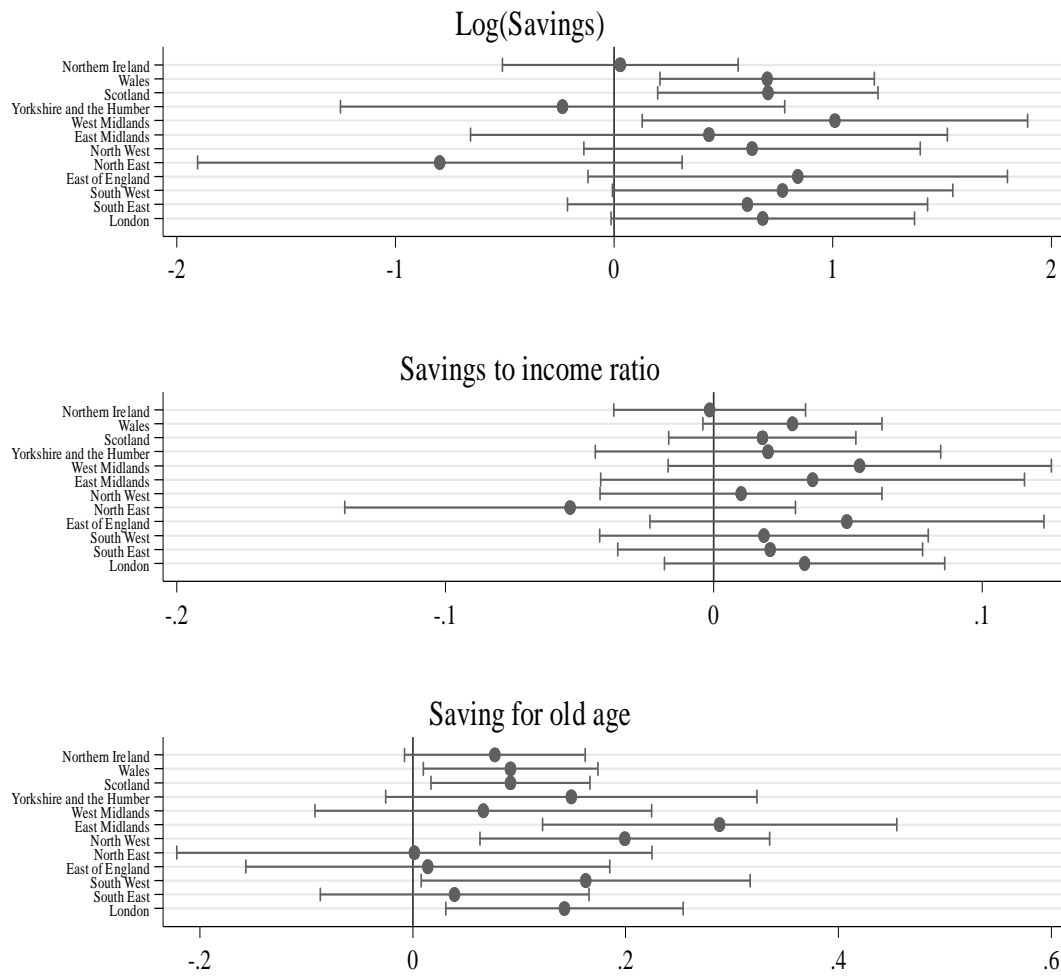


Figure 2

Defined-contribution plans and saving behaviours across British regions

This figure presents the interactions of defined-contributions plan participation with region for the selection of savings variables, i.e., the logarithm of the amount of savings, the ratio of savings to income and the variable for saving for old age. The interactions are from separate weighted instrumental variables IV models, with robust standard errors.

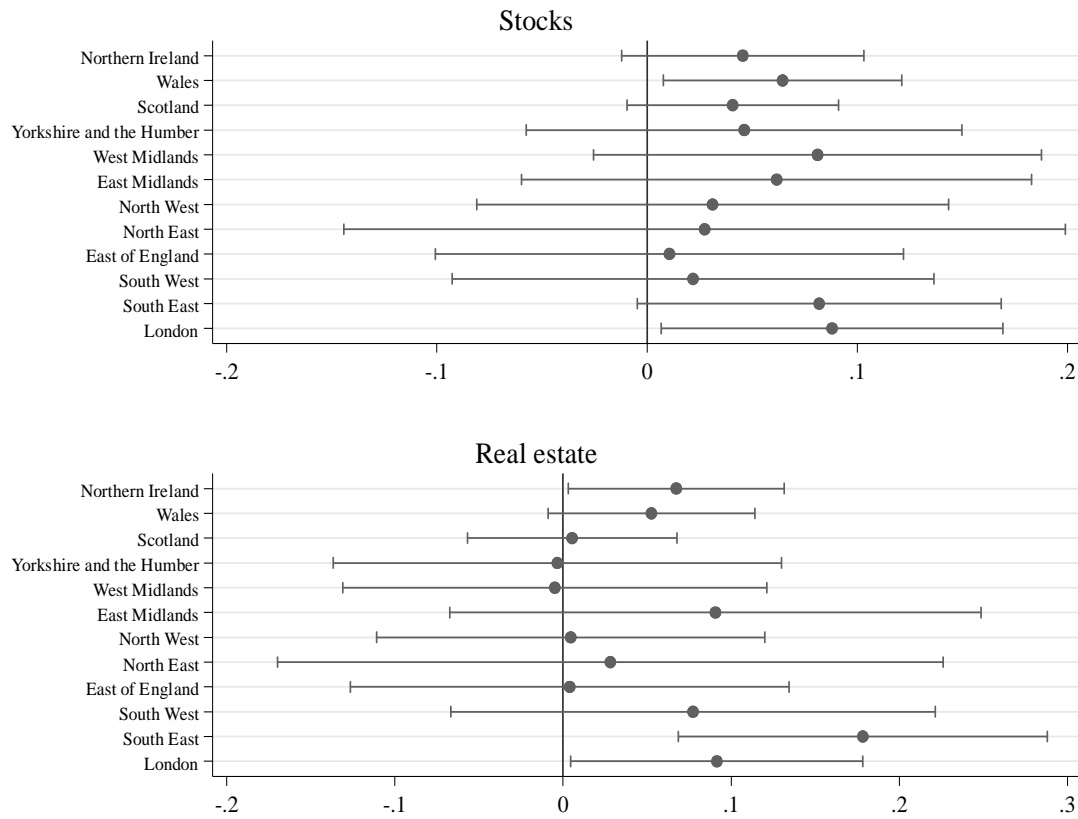


Figure 3

Defined-contribution plans and investing behaviours across British regions

This figure presents the interactions of defined-contributions plan participation with region for the selection of investing variables, i.e., investing in stocks (liquid assets) and in real estate for retirement purposes (illiquid assets). The interactions are from separate weighted instrumental variables IV models, with robust standard errors.

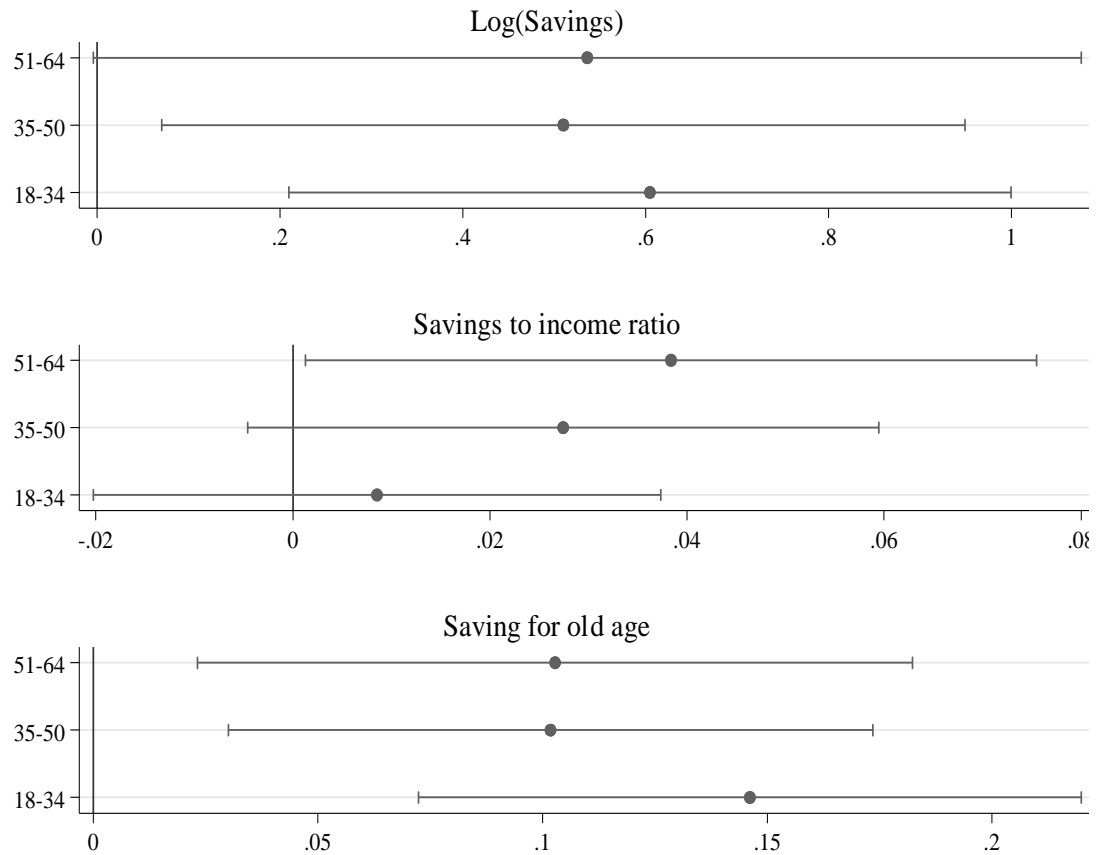


Figure 4

Defined-contribution plans and saving behaviours over the lifecycle

This figure presents the interactions of defined-contribution plan participation with age for the selection of investing variables, i.e., investing in stocks (liquid assets) and in real estate for retirement purposes (illiquid assets). The interactions are from separate weighted instrumental variables IV models, with robust standard errors.

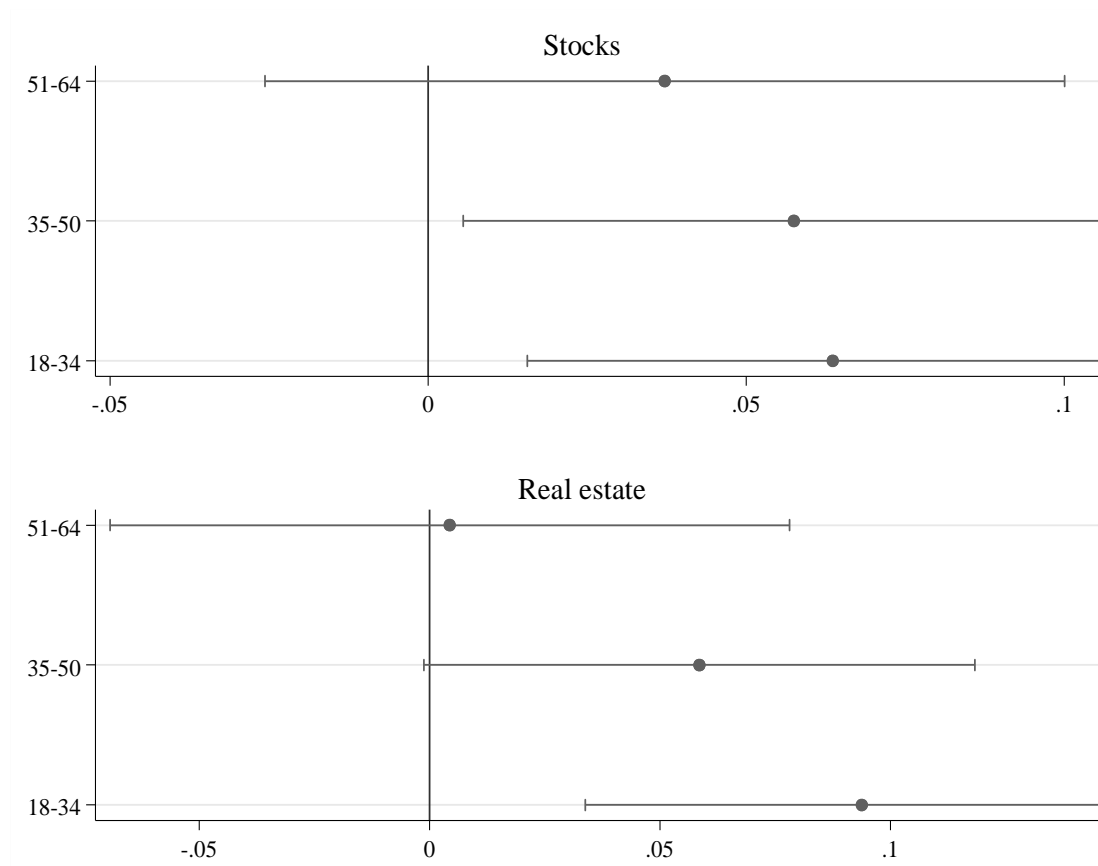


Figure 5

Defined-contribution plans and investing behaviours over the lifecycle.

This figure presents the interactions of defined-contributions plan participation with age for the selection of investing variables, i.e., investing in stocks (liquid assets) and in real estate for retirement purposes (illiquid assets). The interactions are from separate weighted instrumental variables IV models, with robust standard errors.

Table 1

Summary statistics (based on a weighted sample of 4,082 observations)

This table shows the summary statistics on the baseline determinants used in the analysis. The sample consists of working-life individuals aged 18-64 years old. It is also a representative sample of the four nations in the United Kingdom. Column 1 starts with the summary statistics in the pooled sample of 4,082 individuals, while columns 2-5 follow with the respective sample of DC, DB, both DC and DB and no pension planners. DC represents the individuals who own a Defined Contribution pension plan. DB refers to those who contribute to a Defined-Benefits pension plan. Both refers to those who own the same time a DC and DB pension plan. Moreover, the table shows the two variables that instrument Defined Contributions pension plan participation in the IV regressions and the moderating variables suggested in the causal mediation analysis, namely retirement security, financial literacy, seeking financial or retirement professional advice and whether the individuals used more than one information sources during the last year. The t-tests presented in the last 2 columns are from weighted differences between DC and DB pension planners. The asterisks denote the following levels of significance: ***: <0.01, **: <0.05, *: <0.1.

	Pooled	DC	DB	Both	None	Diff.	Sig.
<i>#Observations</i>	4,082	1,129 (27.7%)	1,133 (27.8%)	292 (7.1%)	1,528 (37.4%)		
	(1)	(2)	(3)	(4)	(5)	(2) vs. (3)	
<i>Panel A: Demographic characteristics</i>							
Age	39.65	39.85	42.95	45.82	35.84	-3.100***	
Male	50.2%	50.5%	51.4%	68.9%	45.0%	-0.0090	
Education: Postgraduate	17.4%	17.9%	22.2%	23.6%	12.4%	-0.0043***	
-"-: University degree	20.7%	25.3%	19.5%	25.2%	16.7%	0.0580	
-"-: Vocational	19.8%	19.8%	20.3%	22.6%	18.9%	-0.0005	
-"-: Secondary	15.9%	15.8%	13.5%	10.9%	18.8%	0.0230	
-"-: Primary	18.2%	17.0%	18.5%	13.2%	20.2%	-0.0150	
-"-: No qualifications	7.3%	3.4%	5.2%	4.3%	12.5%	-0.0180	
Ethnicity: White	90.6%	91.4%	93.8%	92.1%	87.5%	-0.0240	
Marital status: Single	41.0%	40.8%	29.7%	23.9%	52.7%	0.1110***	
-"-: Married	49.8%	51.0%	59.1%	63.2%	39.5%	-0.0810***	
-"-: Widowed/Divorced	9.2%	8.2%	11.3%	12.9%	7.8%	-0.0310	
Number of children	0.707	0.720	0.731	0.795	0.660	-0.0110	
Urbanisation: Large city	54.9%	52.8%	53.0%	52.9%	58.4%	-0.0002	
-"-: Small city	32.2%	33.2%	32.0%	33.1%	31.3%	0.0120	
-"-: Village	12.9%	14.1%	15.0%	14.0%	10.3%	-0.0009	
Home ownership: Outright	16.5%	13.5%	25.5%	17.6%	12.6%	-0.1200***	
-"-: Mortgage	41.9%	51.6%	45.7%	58.0%	27.8%	0.0590	
Gross household income	28,370	34,691	31,326	35,443	19,612	3,365	
Present orientation	3.515	3.399	3.189	3.126	3.921	0.2100	
Employment status: Employed	17.4%	17.9%	22.2%	23.6%	12.4%	-0.0430	
-"-: Self-employed	20.7%	25.3%	19.5%	25.2%	16.7%	0.0580	
-"-: Unemployed	19.8%	19.8%	20.3%	22.6%	18.9%	-0.0050	
-"-: Student	15.9%	15.8%	13.5%	10.9%	18.8%	0.0230	
-"-: Homemaker	18.2%	17.0%	18.5%	13.2%	20.2%	-0.0150	
England	83.5%	83.4%	79.9%	84.6%	85.9%	0.0350	
Scotland	8.7%	9.8%	10.5%	9.6%	6.5%	-0.0700	
Wales	4.9%	4.5%	6.1%	3.7%	4.6%	-0.0160	
Northern Ireland	2.9%	2.3%	3.5%	2.1%	3.1%	-0.0120	
<i>Panel B: Household financial outcomes</i>							
Dependent on pensions only	25.8%	24.0%	29.7%	21.3%	25.4%	-0.0570	
Dependent on state pension	14.7%	10.5%	12.1%	8.7%	21.3%	-0.0160	
Pension and investments	40.3%	53.9%	46.9%	54.3%	21.7%	0.0700	
Something else than pension/invest	7.6%	9.0%	9.7%	7.4%	5.0%	-0.0070	
Pension investing in liquid assets	35.5%	47.7%	39.9%	49.8%	19.3%	0.0780	
Pension investing in illiquid assets	15.3%	22.2%	18.9%	20.3%	6.1%	0.0320	
Savings	10,778	12,539	13,481	15,184	6,507	-0,942***	
Savings to income ratio	0.275	0.262	0.326	0.351	0.233	-0.0640**	
Save for old age	41.7%	51.6%	42.8%	55.8%	29.9%	0.0880	

Stockholding	12.7%	16.6%	13.4%	24.2%	6.3%	0.0320
Illiquid assets investments	17.7%	24.4%	19.8%	21.7%	9.8%	0.0460
Entry post Auto-Enrolment	28.1%	31.8%	22.8%	11.6%	32.5%	0.0900*
Retirement literacy	62.6%	85.0%	61.5%	97.6%	37.2%	0.2350
Retirement security	0.068	0.249	0.441	0.576	-0.449	-0.1920***

Table continued from the last page

	(1)	(2)	(3)	(4)	(5)	(2) vs. (3)
Fin. Literacy: #Correct	1.501	1.788	1.614	1.812	1.120	0.1740
Retirement advice	10.2%	11.2%	9.6%	14.5%	8.9%	0.0160
Financial advice	19.7%	16.4%	22.0%	17.7%	21.3%	-0.0560***
Information exposure	33.1%	40.2%	37.6%	40.1%	22.7%	0.0260

Table 2

Pension plan participation in the United Kingdom – First stage of the Heckman model

This table shows estimates from weighted regressions for the first stage of the Heckman model on whether the individuals choose to contribute to a pension plan. The first two columns are estimates from linear probability models on pension plan participation with column A₀ including only the exclusion criterion and column A₁ adding the two instruments used later for Defined-contributions plans. Column B₁ show the estimated marginal effects from the Probit model that calculates the Inverse Mills ratio for the Heckman correction. Finally, columns C₁-C₃ are estimates from a multinomial Probit model without Heckman correction for robustness where the base category is not participating in a pension plan and the rest include participation in Defined-contributions, Defined-benefits and a mix of both respectively. All columns include region fixed effects (12). Robust standard errors are presented in parentheses. Regressions are weighted in the population. The asterisks denote the following levels of significance: ***: <0.01, **: <0.05, *: <0.1.

	<i>LPM</i>		<i>Probit</i>	<i>Multinomial Probit</i>		
	(A ₀)	(A ₁)	(B ₁)	<i>Pension</i>	<i>DK</i>	<i>None</i>
Exclusion restriction: Employee	0.233*** [0.024]	0.216*** [0.023]	0.200*** [0.020]	–	–	–
IV1: Entry post auto-enrolment	–	0.097*** [0.028]	0.095*** [0.028]	0.111*** [0.028]	-0.010 [0.016]	-0.101*** [0.027]
IV2: Retirement literacy	–	0.121*** [0.012]	0.121*** [0.012]	0.129*** [0.012]	-0.058*** [0.009]	-0.072*** [0.012]
Age	0.006*** [0.001]	0.007*** [0.001]	0.007*** [0.001]	0.007*** [0.001]	0.002*** [0.001]	-0.009*** [0.001]
Male	0.034* [0.020]	0.013 [0.020]	0.014 [0.019]	0.038* [0.019]	0.011 [0.011]	-0.049** [0.019]
Present orientation	-0.014*** [0.004]	-0.011*** [0.004]	-0.010*** [0.004]	-0.013*** [0.004]	0.004** [0.002]	0.009** [0.004]
Education: Postgraduate	0.227*** [0.045]	0.173*** [0.045]	0.169*** [0.045]	0.218*** [0.044]	0.013 [0.026]	-0.231*** [0.044]
"-: Undergraduate	0.217*** [0.041]	0.170*** [0.041]	0.166*** [0.042]	0.205*** [0.041]	0.021 [0.024]	-0.226*** [0.040]
"-: Vocational	0.115*** [0.039]	0.082** [0.039]	0.080** [0.039]	0.116*** [0.039]	0.044** [0.022]	-0.160*** [0.038]
"-: Secondary	0.125*** [0.042]	0.095** [0.042]	0.082* [0.043]	0.108** [0.043]	0.032 [0.023]	-0.140*** [0.042]
"-: Primary	0.073* [0.040]	0.064 [0.039]	0.061 [0.039]	0.086** [0.039]	0.031 [0.021]	-0.117*** [0.038]
"-: None/Incomplete	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
White	0.027 [0.039]	0.024 [0.038]	0.016 [0.036]	0.028 [0.036]	0.011 [0.021]	-0.039 [0.035]
Marital status: Single	-0.011 [0.027]	-0.008 [0.026]	-0.005 [0.025]	-0.006 [0.025]	0.024 [0.015]	-0.017 [0.025]
"-: Married	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
"-: Widowed/Divorced	0.057 [0.035]	0.061* [0.034]	0.058* [0.033]	0.053 [0.035]	-0.005 [0.017]	-0.048 [0.036]
Number of children	0.001 [0.012]	0.001 [0.011]	0.001 [0.011]	0.008 [0.011]	-0.005 [0.006]	-0.003 [0.011]
Log(household income)	-0.311 [0.213]	-0.409*** [0.205]	-0.374 [0.228]	-0.642*** [0.226]	0.046 [0.121]	0.597*** [0.214]
Log(household income) ²	0.039 [0.031]	0.054* [0.030]	0.049 [0.033]	0.085*** [0.033]	-0.009 [0.018]	-0.076** [0.031]
Log(household income) ³	-0.001 [0.001]	-0.002 [0.001]	-0.002 [0.001]	-0.003** [0.001]	0.001 [0.001]	0.003** [0.001]
Home ownership: outright	0.047* [0.028]	0.04 [0.027]	0.028 [0.025]	0.04 [0.025]	-0.008 [0.014]	-0.032 [0.025]

Table continued from the last page

	(A ₀)	(A ₁)	(B ₁)	(C ₁)	(C ₂)	(C ₃)
-": Mortgage	0.084*** [0.026]	0.082*** [0.026]	0.074*** [0.023]	0.098*** [0.023]	0.013 [0.013]	-0.110*** [0.023]
-": None	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
Urbanity: Large city	-0.040* [0.023]	-0.039* [0.022]	-0.040* [0.022]	-0.035 [0.022]	0.008 [0.013]	0.027 [0.022]
-": Small city/suburbs	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
-": Village	-0.012 [0.030]	-0.019 [0.029]	-0.01 [0.030]	-0.007 [0.031]	0.011 [0.016]	-0.004 [0.031]
<i>% Employee effect</i>	42.1%	38.9%	36.2%	–	–	–
<i>%Entry post auto-enrolment effect</i>	–	17.5%	17.1%	20.1%	-13.1%	-27.4%
<i>Predicted probability</i>	0.555	0.555	0.5539	0.554	0.078	0.368
<i>No. of Observations</i>	4,082	4,082	4,082	4,082	4,082	4,082

Table 3

Defined-contribution plan participation in the United Kingdom

This table shows the estimates of weighted regressions on the determinants of Defined-contributions pension plan participation in the United Kingdom. Columns A₁, B₁ and C₁ show marginal effects estimates from Probit regressions after Heckman correction. Column A₁ and B₁ include the two instruments individually whereas column C₁ shows the estimates when they are both included. The Inverse-Mills ratio is included in every specification to correct for sample selection bias. Columns D₁-D₄ show the estimates from a multinomial Probit model without Heckman correction where the base category is not participating in a pension plan and the rest are participation in Defined-contributions, Defined-benefits and a mix of both plans. All columns include region fixed effects (12). Robust standard errors are presented in parentheses. Regressions are weighted in the population. The asterisks denote the following levels of significance: ***: <0.01, **: <0.05, *: <0.1.

	<u>Heckman Probit</u>			<u>Multinomial Probit</u>			
	<i>Defined Contribution</i>			<i>DC</i>	<i>DB</i>	<i>Both</i>	<i>None</i>
	(A ₁)	(B ₁)	(C ₁)	(D ₁)	(D ₃)	(D ₂)	(D ₄)
IV1 : Entrant Post Auto-Enrolment	0.264*** [0.087]	–	0.252*** [0.088]	0.081*** [0.029]	0.038 [0.028]	-0.023 [0.018]	-0.096*** [0.027]
IV2: Retirement literacy	–	0.364*** [0.039]	0.362*** [0.039]	0.083*** [0.012]	-0.023** [0.011]	0.020*** [0.007]	-0.080*** [0.012]
Inverse Mills Ratio	0.258*** [0.054]	0.379*** [0.055]	0.387*** [0.055]	–	–	–	–
Age	0.020*** [0.004]	0.012*** [0.003]	0.018*** [0.004]	0.001 [0.001]	0.005*** [0.001]	0.003*** [0.001]	-0.009*** [0.001]
Male	0.182*** [0.060]	0.094 [0.061]	0.099 [0.061]	-0.001 [0.020]	0.003 [0.019]	0.048*** [0.012]	-0.049*** [0.019]
Present orientation	-0.014 [0.012]	-0.008 [0.012]	-0.007 [0.012]	0.001 [0.004]	-0.006 [0.004]	-0.002 [0.002]	0.008** [0.004]
Education: Postgraduate	0.581*** [0.139]	0.429*** [0.143]	0.428*** [0.143]	0.057 [0.047]	0.113** [0.047]	0.065** [0.027]	-0.235*** [0.044]
"-": Undergraduate	0.712*** [0.131]	0.579*** [0.134]	0.580*** [0.134]	0.110** [0.044]	0.056 [0.045]	0.060** [0.026]	-0.225*** [0.041]
"-": Vocational	0.469*** [0.125]	0.335*** [0.128]	0.345*** [0.129]	0.074* [0.043]	0.048 [0.043]	0.039 [0.025]	-0.161*** [0.039]
"-": Secondary	0.440*** [0.134]	0.318** [0.138]	0.325** [0.138]	0.068 [0.046]	0.044 [0.047]	0.026 [0.027]	-0.138*** [0.042]
"-": Primary	0.326*** [0.126]	0.292** [0.128]	0.289** [0.129]	0.076* [0.043]	0.033 [0.042]	0.009 [0.026]	-0.118*** [0.038]
"-": None/Incomplete	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
White	-0.017 [0.110]	-0.04 [0.112]	-0.04 [0.112]	-0.007 [0.035]	0.055 [0.037]	-0.008 [0.023]	-0.041 [0.035]
Marital status: Single	0.136* [0.078]	0.139* [0.079]	0.140* [0.079]	0.050* [0.025]	-0.031 [0.024]	-0.005 [0.014]	-0.014 [0.025]
"-": Married	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
"-": Widowed/Divorced	0.14 [0.110]	0.175 [0.109]	0.176 [0.108]	0.021 [0.035]	0.01 [0.032]	0.017 [0.018]	-0.048 [0.036]
Number of children	0.014 [0.034]	-0.015 [0.034]	-0.005 [0.034]	-0.002 [0.011]	0.003 [0.011]	0.003 [0.006]	-0.004 [0.011]
Log(household income)	-2.302*** [0.764]	-2.711*** [0.766]	-2.607*** [0.771]	-1.250*** [0.258]	0.286 [0.219]	0.337** [0.135]	0.627*** [0.215]
Log(household income) ²	0.307*** [0.110]	0.369*** [0.110]	0.355*** [0.111]	0.174*** [0.037]	-0.044 [0.032]	-0.050** [0.020]	-0.080** [0.031]
Log(household income) ³	-0.012** [0.005]	-0.015*** [0.005]	-0.014*** [0.005]	-0.007*** [0.002]	0.002 [0.001]	0.002** [0.001]	0.003** [0.001]
Home ownership: outright	-0.195** [0.081]	-0.192** [0.083]	-0.201** [0.083]	-0.059** [0.026]	0.100*** [0.024]	-0.011 [0.015]	-0.03 [0.025]
"-": Mortgage	0.239*** [0.073]	0.228*** [0.073]	0.235*** [0.073]	0.048** [0.024]	0.038* [0.023]	0.022 [0.013]	-0.107*** [0.023]
"-": None	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}

Table continued from the last page

	(A ₁)	(B ₁)	(C ₁)	(D ₁)	(D ₃)	(D ₂)	(D ₄)
Urbanity: Large city	-0.103 [0.071]	-0.129* [0.071]	-0.124* [0.072]	-0.038 [0.023]	0.007 [0.022]	0.007 [0.014]	0.024 [0.022]
-"-: Small city/suburbs	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
-"-: Village	-0.014 [0.096]	-0.052 [0.096]	-0.048 [0.097]	0.001 [0.031]	0.013 [0.029]	-0.008 [0.018]	-0.005 [0.031]
<i>% IV1 effect</i>	69.2%	–	66.1%	27.0%	15.2%	-28.0%	-26.1%
<i>% IV2 effect</i>	–	95.4%	95.0%	27.8%	-9.2%	24.4%	-21.8%
<i>Predicted probability</i>	0.3813	0.3817	0.3813	0.2994	0.2507	0.0821	0.3678
<i>No. of Observations</i>	4,082	4,082	4,082	4,082	4,082	4,082	4,082

Table 4

The determinants of retirement finances in the United Kingdom – Endogenous treatment effects models (DC) with Heckman correction for pension plan participation

This table shows estimates from weighted endogenous treatment regressions. Column 1 shows the estimation results on those who base their retirement finances only on pensions, state or workplace. Column 2 continues with the effects on whether individuals depend only in a state pension, while column 3 shows the estimates on those who invest further, in addition to their pension plans. Column 4 shows the effects on having other types of retirement funds besides pensions or investments, while column 5 shows the results on investing in liquid assets for retirement purposes. Column 6 concludes with the effects on investing in illiquid housing assets for later ages. All regressions are maximum likelihood treatment regressions with robust standard errors in parentheses and include the Inverse Mills ratio from the first stage of Heckman for the correction for selection bias and region (12) fixed effects. The asterisks denote the following levels of significance: ***: <0.01, **: <0.05, *: <0.1.

	<i>Pension only</i>	<i>State pension</i>	<i>Pensions + Other</i>	<i>Pension + investments</i>	<i>Pensions + Liquid assets</i>	<i>Pensions + Illiquid assets</i>
	(1)	(2)	(3)	(4)	(5)	(6)
Defined-contribution plan	-0.045 [0.065]	-0.206*** [0.037]	0.054 [0.042]	0.342*** [0.115]	0.337*** [0.114]	0.160*** [0.055]
Inverse Mills Ratio	0.032* [0.018]	-0.007 [0.015]	0.015 [0.009]	-0.028 [0.020]	-0.03 [0.020]	-0.031** [0.015]
Age	0.003*** [0.001]	0.001 [0.001]	0.001 [0.001]	0.004*** [0.001]	0.003*** [0.001]	0.002** [0.001]
Male	0.013 [0.019]	0.002 [0.015]	-0.007 [0.012]	-0.023 [0.022]	-0.009 [0.021]	-0.037** [0.016]
Present orientation	0.019*** [0.004]	0.014*** [0.003]	0.004 [0.003]	-0.025*** [0.004]	-0.027*** [0.004]	-0.004 [0.003]
Education: Postgraduate	-0.114** [0.047]	-0.134*** [0.041]	-0.005 [0.024]	0.136*** [0.047]	0.134*** [0.044]	0.047 [0.033]
-": Undergraduate	-0.149*** [0.045]	-0.154*** [0.038]	-0.004 [0.024]	0.214*** [0.048]	0.215*** [0.045]	0.068** [0.033]
-": Vocational	-0.151*** [0.043]	-0.160*** [0.038]	0.032 [0.022]	0.113*** [0.040]	0.094** [0.037]	0.027 [0.029]
-": Secondary	-0.152*** [0.044]	-0.179*** [0.039]	0.04 [0.025]	0.109** [0.043]	0.115*** [0.040]	0.043 [0.031]
-": Primary	-0.078* [0.043]	-0.099** [0.039]	0.017 [0.021]	0.058 [0.038]	0.074** [0.035]	-0.02 [0.027]
-": None/Incomplete	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
White	0.086*** [0.029]	0.046* [0.024]	0.018 [0.018]	0.04 [0.036]	0.03 [0.035]	-0.017 [0.027]
Marital status: Single	0.001 [0.025]	-0.028 [0.020]	-0.036** [0.016]	0.048* [0.026]	0.069*** [0.026]	0.028 [0.020]
-": Married	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
-": Widowed/Divorced	0.077** [0.036]	0.034 [0.030]	-0.040** [0.019]	-0.018 [0.038]	-0.026 [0.037]	0.012 [0.032]
Number of children	0.022** [0.011]	0.017* [0.009]	0.005 [0.007]	-0.027** [0.011]	-0.024** [0.011]	-0.001 [0.009]
Log(household income)	-0.429** [0.206]	-0.102 [0.183]	0.063 [0.123]	0.077 [0.227]	0.159 [0.225]	0.025 [0.156]
Log(household income) ²	0.065** [0.030]	0.016 [0.026]	-0.009 [0.018]	-0.017 [0.033]	-0.028 [0.033]	-0.007 [0.023]
Log(household income) ³	-0.003** [0.001]	-0.001 [0.001]	0.001 [0.001]	0.001 [0.001]	0.001 [0.001]	0.001 [0.001]
Home ownership: outright	-0.079*** [0.025]	-0.051** [0.021]	-0.016 [0.016]	0.128*** [0.029]	0.107*** [0.029]	0.088*** [0.020]
-": Mortgage	-0.033	-0.029	-0.041***	0.115***	0.047*	0.150***

	[0.025]	[0.021]	[0.015]	[0.028]	[0.027]	[0.020]
<i>Table continued from the last page</i>						
	(1)	(2)	(4)	(3)	(5)	(6)
"-": None	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
Urbanity: Large city	0.013 [0.022]	0.005 [0.017]	0.01 [0.014]	-0.026 [0.025]	-0.026 [0.025]	-0.007 [0.019]
"-": Small city/suburbs	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
"-": Village	-0.021 [0.031]	-0.01 [0.024]	-0.007 [0.019]	0.036 [0.034]	0.014 [0.033]	0.036 [0.030]
<i>% DC effect</i>	<i>-17.3%</i>	<i>-140.0%</i>	<i>71.3%</i>	<i>84.9%</i>	<i>95.0%</i>	<i>104.7%</i>
<i>Predicted probability</i>	<i>0.2575</i>	<i>0.1473</i>	<i>0.0758</i>	<i>0.4033</i>	<i>0.3547</i>	<i>0.1528</i>
<i>No. of Observations</i>	<i>4,082</i>	<i>4,082</i>	<i>4,082</i>	<i>4,082</i>	<i>4,082</i>	<i>4,082</i>

Table 5

Pension plans and household financial behaviour in the United Kingdom – Endogenous treatment effects models (DC) with Heckman correction for pension plan participation

This table shows the estimation results for the dependent variables on retirement finances. Column 1 shows the estimation results on the logarithm of the amount of savings. Column 2 continues with the effects on the ratio of savings to income, while column 3 shows the estimates on saving for old age, owning stocks or have made other real estate investments for retirements respectively. All regressions are maximum likelihood treatment regressions with robust standard errors in parentheses, including the Inverse Mills ratio for the Heckman correction and region (12) fixed effects. The results are weighted in the population. Finally, the three instrument-validity tests are reported for each regression. The asterisks denote the following levels of significance: ***: <0.01, **: <0.05, *: <0.1.

	<i>Log (Savings)</i>	<i>Savings to income</i>	<i>Saving for old age</i>	<i>Stocks</i>	<i>Real estate</i>
	(1)	(2)	(3)	(4)	(5)
Defined-contribution plan	2.309*** [0.290]	0.201*** [0.036]	0.293** [0.114]	0.137*** [0.043]	0.157** [0.063]
Inverse Mills Ratio	0.115 [0.088]	-0.019* [0.010]	-0.045** [0.021]	-0.022* [0.012]	-0.032** [0.016]
Age	0.012** [0.005]	0.002*** [0.001]	0.001 [0.001]	0.002*** [0.001]	0.001 [0.001]
Male	0.056 [0.099]	0.003 [0.010]	0.005 [0.022]	0.034** [0.015]	-0.035** [0.017]
Present orientation	-0.308*** [0.021]	-0.021*** [0.002]	-0.033*** [0.004]	-0.013*** [0.003]	-0.004 [0.003]
Education: Postgraduate	1.387*** [0.213]	0.108*** [0.023]	0.187*** [0.045]	0.051* [0.030]	0.058 [0.035]
-": Undergraduate	1.238*** [0.182]	0.071*** [0.023]	0.241*** [0.046]	0.035 [0.027]	0.077** [0.034]
-": Vocational	0.644*** [0.194]	0.044** [0.020]	0.116*** [0.038]	0.024 [0.024]	0.045 [0.030]
-": Secondary	0.904*** [0.209]	0.060*** [0.022]	0.138*** [0.041]	0.024 [0.028]	0.05 [0.032]
-": Primary	0.546*** [0.191]	0.044** [0.021]	0.121*** [0.036]	-0.035* [0.020]	-0.003 [0.028]
-": None/Incomplete	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
White	-0.027 [0.174]	0.029 [0.019]	-0.013 [0.038]	-0.079*** [0.029]	-0.083*** [0.032]
Marital status: Single	0.057 [0.121]	0.015 [0.014]	0.065** [0.027]	0.001 [0.018]	0.004 [0.023]
-": Married	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
-": Widowed/Divorced	-0.126 [0.181]	-0.043* [0.022]	-0.02 [0.038]	0.009 [0.026]	0.001 [0.033]
Number of children	-0.157*** [0.051]	-0.006 [0.007]	-0.012 [0.012]	-0.004 [0.008]	-0.001 [0.010]
Log(household income)	1.918 [1.360]	-0.074 [0.124]	0.450* [0.243]	0.512*** [0.149]	-0.017 [0.169]
Log(household income) ²	-0.401** [0.197]	-0.008 [0.018]	-0.068* [0.035]	-0.081*** [0.022]	0.001 [0.025]
Log(household income) ³	0.023*** [0.009]	0.001 [0.001]	0.003** [0.002]	0.004*** [0.001]	0.001 [0.001]
Home ownership: outright	1.791*** [0.135]	0.154*** [0.014]	0.100*** [0.030]	0.110*** [0.022]	0.124*** [0.022]
-": Mortgage	0.674*** [0.144]	0.029** [0.014]	0.038 [0.028]	-0.009 [0.016]	0.177*** [0.021]
-": None	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
Urbanity: Large city	0.220* [0.130]	0.016 [0.012]	0.008 [0.026]	-0.011 [0.016]	0.008 [0.020]

Table continued from the last page

	(1)	(2)	(3)	(4)	(5)
-": Small city/suburbs	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
-": Village	0.088 [0.155]	-0.002 [0.017]	0.026 [0.034]	0.012 [0.024]	0.025 [0.030]
Under-identification test (Kleibergen-Paap LM statistic)	86.700***	86.700***	86.700***	86.700***	86.700***
Weak identification test (Cragg-Donald Wald F statistic)	98.621	98.621	98.621	98.621	98.621
Stock-Yogo weak ID test critical values	19.930	19.930	19.930	19.930	19.930
Hansen J statistic	0.019	0.535	1.901	2.656	0.789
% DC effect	34.2%	73.2%	70.1%	108.3%	88.6%
Predicted probability	6.7533	0.2747	0.4175	0.1266	0.1768
No. of Observations	4,082	4,082	4,082	4,082	4,082

Table 6

Causal mediation analysis: Pension plans and household financial behaviour in the United Kingdom – 2SLS regressions with Heckman correction for pension plan participation

This table shows the estimates from the causal mediation analysis on pension plans and household financial behaviour in the United Kingdom. The regressions are second stage 2SLS regressions with Heckman correction for pension plan participation. Five variables are considered as mediators on Defined-contributions plan participation, those being financial literacy, information exposure, retirement security, retirement advice and financial advice. Column 1 shows the causal mediation analysis estimates for financial literacy, with column 2 continuing with those of information exposure. Column 3 shows the estimates for retirement security and columns 4-5 conclude with those for retirement and financial advice respectively. The results are weighted at the population level. The asterisks denote the following levels of significance: ***: <0.01, **: <0.05, *: <0.1.

	<i>Log (Savings)</i>	<i>Savings to income</i>	<i>Saving for old age</i>	<i>Stocks</i>	<i>Real estate</i>
Panel A:	(A ₁)	(A ₂)	(A ₃)	(A ₄)	(A ₅)
Financial literacy	4.020*** [1.091]	0.169** [0.073]	0.353** [0.171]	0.287** [0.130]	0.298** [0.150]
Defined Contributions Plan	0.137 [0.188]	0.007 [0.012]	0.079*** [0.029]	0.025 [0.021]	0.027 [0.024]
<i>Total effect</i>	3.2143	0.1476	0.2872	0.1976	0.2226
<i>Direct effect</i>	0.1371	0.0067	0.0791	0.0247	0.0271
<i>Indirect effect</i>	3.0772	0.1409	0.2081	0.1729	0.1956
<i>Mediation effect</i>	95.7%	95.4%	72.5%	87.5%	87.9%
Panel B:	(B ₁)	(B ₂)	(B ₃)	(B ₄)	(B ₅)
Information sources	8.534*** [3.202]	0.392** [0.179]	0.571 [0.353]	0.475* [0.278]	0.539* [0.305]
Defined Contributions Plan	-0.036 [0.327]	-0.003 [0.017]	0.076** [0.035]	0.022 [0.026]	0.021 [0.029]
<i>Total effect</i>	3.2143	0.1476	0.2872	0.1976	0.2226
<i>Direct effect</i>	-0.0355	-0.0028	0.0763	0.0216	0.0207
<i>Indirect effect</i>	3.2499	0.1504	0.2109	0.176	0.202
<i>Mediation effect</i>	101.1%	101.9%	73.4%	89.1%	90.7%
Panel C:	(C ₁)	(C ₂)	(C ₃)	(C ₄)	(C ₅)
Retirement security	2.312*** [0.386]	0.101*** [0.031]	0.250** [0.118]	0.152*** [0.046]	0.154** [0.068]
Defined Contributions Plan	0.386*** [0.137]	0.017* [0.010]	0.093*** [0.023]	0.042*** [0.016]	0.048** [0.019]
<i>Total effect</i>	2.4942	0.1324	0.3433	0.1465	0.2279
<i>Direct effect</i>	0.3861	0.0167	0.0935	0.0417	0.048
<i>Indirect effect</i>	2.1081	0.1157	0.2498	0.1048	0.1799
<i>Mediation effect</i>	84.5%	87.4%	72.8%	71.5%	79.0%
Panel D	(D ₁)	(D ₂)	(D ₃)	(D ₄)	(D ₅)
Retirement advice	17.265** [8.095]	0.804* [0.439]	1.097 [0.787]	0.918 [0.608]	1.061 [0.685]
Defined Contributions Plan	0.343 [0.300]	0.014 [0.016]	0.102*** [0.029]	0.043** [0.022]	0.045* [0.025]
<i>Total effect</i>	3.2143	0.1476	0.2872	0.1976	0.2226
<i>Direct effect</i>	0.3425	0.0144	0.1023	0.0432	0.0449
<i>Indirect effect</i>	2.8718	0.1332	0.1849	0.1544	0.1777
<i>Mediation effect</i>	89.3%	90.2%	64.4%	78.1%	79.8%
Panel E	(E ₁)	(E ₂)	(E ₃)	(E ₄)	(E ₅)
Financial advice	9.306** [4.037]	0.498* [0.260]	0.249 [0.440]	0.239 [0.311]	0.394 [0.370]
Defined Contributions Plan	0.920*** [0.271]	0.044** [0.017]	0.125*** [0.030]	0.064*** [0.021]	0.073*** [0.026]

Table continued from the last page

<i>Total effect</i>	3.2143	0.1476	0.2872	0.1976	0.2226
<i>Direct effect</i>	0.9205	0.0438	0.1255	0.0638	0.0734
<i>Indirect effect</i>	2.2939	0.1038	0.1617	0.1338	0.1492
<i>Mediation effect</i>	71.4%	70.3%	56.3%	67.7%	67.0%
<i>Predicted probability</i>	6.9477	0.2747	0.4175	0.1266	0.1768
<i>No. of Observations</i>	4,082	4,082	4,082	4,082	4,082

References

- Financial Capability Survey, (2018). [Data collection]. Second Edition. UK Data Service. SN: 8454, DOI: 10.5255/UKDA-SN-8454-2
- Anderson, A., Baker, F. and Robinson, D.T. (2017). Precautionary savings, retirement planning and misperceptions of financial literacy. *Journal of Financial Economics*, 126(2), pp. 383-398.
- Banks, J., o’Dea, C. and Oldfield, Z. (2010). Cognitive function, numeracy and retirement saving trajectories. *The Economic Journal*, 120(548), pp. F381-F410.
- Benartzi, S. and Thaler, R.H. (2013). Behavioral economics and the retirement savings crisis. *Science*, 339(6124), pp. 1152-1153.
- Bodie, Z. (2003). An analysis of investment advice to retirement plan participants. *The pension challenge: Risk transfers and retirement income security*, pp. 19-32.
- Börsch-Supan, A., Bucher-Koenen, T., Kutlu-Koc, V. and Goll, N. (2018). Dangerous flexibility–retirement reforms reconsidered. *Economic Policy*, 33(94), pp. 315-355.
- Card, D. and Ransom, M. (2011). Pension plan characteristics and framing effects in employee savings behaviour. *The Review of Economics and Statistics*, 93(1), pp. 228-243.
- Chatterjee, S. and Fan, L. (2023). Surviving in financial advice deserts: limited access to financial advice and retirement planning behaviour. *International Journal of Bank Marketing*, 41(1), pp. 70-106.
- Choi, J.J. (2015). Contributions to defined contribution pension plans. *Annual Review of Financial Economics*, 7, pp. 161-178.
- Collins, J.M. and Urban, C. (2016). The role of information on retirement planning: Evidence from a field study. *Economic Inquiry*, 54(4), pp. 1860-1872.
- Cribb, J. and Emmerson, C. (2016). What happens when employers are obliged to nudge? Automatic enrolment and pension saving in the UK. Institute for Fiscal Studies Report. Published: 17/11/2016
- Curry, C. (2008). The introduction of auto-enrolment and personal accounts to the UK in 2012. *Pensions: An International Journal*, 13, pp. 237-245.
- Dippel, C., Gold, R., Heblich, S. and Pinto, R. (2022). The effect of trade on workers and voters. *The Economic Journal*, 132(641), pp. 199-217.
- Disney, R. and Gathergood, J. (2013). Financial literacy and consumer credit portfolios. *Journal of Banking & Finance*, 37(7), pp. 2246-2254.
- Duflo, E. and Saez, E. (2003). The role of information and social interactions in retirement plan decisions: Evidence from a randomized experiment. *The Quarterly Journal of Economics*, 118(3), pp. 815-842.
- Ekerdt, D.J., De Viney, S. and Kosloski, K. (1996). Profiling plans for retirement. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 51(3), pp. S140-S149.

- Farrar, S., Moizer, J., Lean, J. and Hyde, M. (2019). Gender, financial literacy, and preretirement planning in the UK. *Journal of Women & Aging*, 31(4), pp. 319-339.
- Fornero, E. and Monticone, C. (2011). Financial literacy and pension plan participation in Italy. *Journal of Pension Economics & Finance*, 10(4), pp. 547-564.
- Foster, L. (2017). Young people and attitudes towards pension planning. *Social Policy and Society*, 16(1), pp. 65-80.
- Foster, L. (2018). Active ageing, pensions and retirement in the UK. *Journal of Population Ageing*, 11, pp. 117-132.
- Foster, L., Wijeratne, D. and Mulligan, E. (2021). Gender and proposed Auto-enrolment in the Republic of Ireland: Lessons from the UK. *Social Policy & Administration*, 55(1), pp. 143-156.
- Gathergood, J. (2012). Self-control, financial literacy and consumer over-indebtedness. *Journal of Economic Psychology*, 33(3), pp. 590-602.
- Gathergood, J. and Disney, R.F. (2011). Financial literacy and indebtedness: New evidence for UK consumers. Available at SSRN: <https://ssrn.com/abstract=1851343>.
- Ginn, J. and MacIntyre, K. (2013). UK pension reforms: is gender still an issue? *Social Policy and Society*, 12(1), pp. 91-103.
- Heckman, J.J. (1979). Sample selection bias as a specification error. *Econometrica: Journal of the econometric society*, pp. 153-161.
- Hoffmann, A.O. and Plotkina, D. (2020). Why and when does financial information affect retirement planning intentions and which consumers are more likely to act on them? *Journal of Business Research*, 117, pp. 411-431.
- Hussain, J., Salia, S. and Karim, A. (2018). Is knowledge that powerful? Financial literacy and access to finance: An analysis of enterprises in the UK. *Journal of Small Business and Enterprise Development*, 25(6), pp. 985-1003.
- Lusardi, A. (2008). Financial literacy: an essential tool for informed consumer choice? National Bureau of Economic Research Working Papers, no.14084
- Lusardi, A., Michaud, P. and Mitchell, O.S. (2017). Optimal financial knowledge and wealth inequality. *Journal of Political Economy*, 125(2), pp. 431-477.
- Lusardi, A. and Mitchell, O.S. (2011). Financial literacy and retirement planning in the United States. *Journal of Pension Economics & Finance*, 10(4), pp. 509-525.
- Marsden, M., Zick, C.D. and Mayer, R.N. (2011). The value of seeking financial advice. *Journal of Family and Economic Issues*, 32, pp. 625-643.
- McGowan, F.P. and Lunn, P.D. (2020). Supporting decision-making in retirement planning: Do diagrams on Pension Benefit Statements help? *Journal of Pension Economics & Finance*, 19(3), pp. 323-343.
- Merton, R.C. (2014). The crisis in retirement planning. *Harvard Business Review*, 92(7/8), pp. 43-50.

- Mitchell, O.S. and Utkus, S.P. (2022). Target-date funds and portfolio choice in 401 (k) plans. *Journal of Pension Economics & Finance*, 21(4), pp. 519-536.
- Montagnoli, A., Moro, M., Panos, G.A. and Wright, R. (2016). Financial literacy and political orientation in Great Britain. *IZA Discussion Papers*, no.10285
- Montagnoli, A., Moro, M., Panos, G.A. and Wright, R. (2017). Financial literacy and attitudes to redistribution. *IZA Discussion Papers*, no.10633
- Newson, R.B., 2008, September. *parmet* and extensions. United Kingdom Stata Users Group Meetings 2008-07, Stata Users Group.
- Nicolini, G., Cude, B.J. and Chatterjee, S. (2013). Financial literacy: A comparative study across four countries. *International Journal of Consumer Studies*, 37(6), pp. 689-705.
- Ring, P.J. (2012). Trust: a challenge for private pension policy. *Journal of Comparative Social Welfare*, 28(2), pp. 119-128.
- Ryan, M. (2021). Preferences for Defined Benefit versus Defined Contribution Retirement Plans: The Impact of Financial Literacy, Risk Tolerance, and Time Orientation (Doctoral dissertation, University of Georgia).
- Seay, M., Kim, K.T. and Heckman, S. (2016). Exploring the demand for retirement planning advice: The role of financial literacy. *Financial Services Review*, 25(4), pp. 331-350.
- Sialm, C., Starks, L.T. and Zhang, H. (2015). Defined contribution pension plans: Sticky or discerning money? *The Journal of Finance*, 70(2), pp. 805-838.
- Smith, J.P., McArdle, J.J. and Willis, R. (2010). Financial decision making and cognition in a family context. *The Economic Journal*, 120(548), pp. F363-F380.
- Wooldridge, J.M. (2010). *Econometric analysis of cross section and panel data*. MIT Press.

Appendix

Appendix Table 1

Variable description for the UK Financial Capability Survey 2018

This table presents the variable definitions for the main dependent and independent variables on retirement finances used in the empirical analysis based on the definitions provided by the Financial Capability Survey of 2018 in the United Kingdom.

Variable name	Definition
Defined Contributions Plan	Thinking about all the years you've paid into a pension, have these been: All or mostly Defined contributions
Defined Benefits Plan	Thinking about all the years you've paid into a pension, have these been: All or mostly Defined benefits
Both DC and DB	Thinking about all the years you've paid into a pension, have these been: A mix of each
No pension plan	Thinking about all the years you've paid into a pension, have these been: Not applicable - I have never paid in
Dependent on pensions only	Which, if any, of the following are you expecting to use to pay for your retirement? 1) State pension or 2) Personal or workplace pension
Dependent on state pension	Which, if any, of the following are you expecting to use to pay for your retirement? State pension
Pension + investments	Which, if any, of the following are you expecting to use to pay for your retirement? 1) State pension or 2) Personal or workplace pension, 3) Savings or investments, 4) Downsizing your home or equity release, 5) Buy-to-let or other income from a property that is not your main home
Pensions + Other	Which, if any, of the following are you expecting to use to pay for your retirement? Something else
Pensions + Liquid assets	Which, if any, of the following are you expecting to use to pay for your retirement? Savings or investments
Pensions + Illiquid assets	Which, if any, of the following are you expecting to use to pay for your retirement? 1) Downsizing your home or equity release, 2) Buy-to-let or other income from a property that is not your main home
Savings	Total personal savings
Savings to income	Ratio of total personal savings to household income
Saving for old age	Which, if any, of the following are you expecting to use to pay for your retirement? Savings
Stocks	Do you currently have savings or investments in any of the following? In investments/stocks & shares
Real estate	Which, if any, of the following are you expecting to use to pay for your retirement? 1) Downsizing your home or equity release, 2) Buy-to-let or other income from a property that is not your main home
Entrant Post Auto-Enrolment	Entrant post auto-enrolment variable created based on the questions for years of labour market experience and pension participation: <i>Thinking about all those years paying into a pension, is it... [value]? and Is your income roughly the same?: Exactly the same every week/fortnight/month</i>

Appendix Table C1 continued at next page

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Variable name	Definition
Retirement literacy	Retirement knowledge score based on correct responses on: <i>John has a pension where: • he pays 4% of his salary • the government pays 1% through tax relief. • His employer pays 5% When he retires, the income he receives will depend on how much his pot is worth. How the stock market has performed will make a difference to his retirement income.: Defined Contribution (DC) and Janet has a pension where: • she pays 6% of her salary • her employer pays whatever is needed to ensure the retirement income is paid according to the formula When she retires, she will receive a pension that is based on the average of her salary throughout the time she was working: Defined Benefit (DB)</i>
Retirement security	Principal Component analysis variable based on: <i>I am roughly on track to have a reasonable income in retirement / How much of an idea do you have about what your financial situation will be in retirement? / For how many years, approximately, do you think you will be retired?</i>
Fin. Literacy: #Correct	Financial literacy score based on questions on: 1) Inflation, 2) Interest, 3) Compound interest calculation
Retirement advice	Over the last 12 months have you done any of these ..?: 1) Spoken to a regulated financial adviser (IFA) about retirement planning, 2) Contacted PensionWise or the Pensions Advisory Service (TPAS)
Financial advice	Is consulting an advice organisation about debt something.....?: 1) Already doing, 2) You are planning to do soon, 3) You are thinking about doing in the future
Information sources	Which of the following sources of information have you used in the last year to find out about anything to do with money – whether that is how to budget or plan your finances, the best insurance, banking or credit products available, how to claim benefits or grants, or to get any help or advice, etc.

Appendix Table 2

Weighted pair-wise correlation matrix, 2018 Financial Capability Survey

	Defined contributions	Entrant post Auto-Enrolment	Retirement literacy	Pension only	State pension	Pensions + Other	Pensions + Investments	Pensions + Liquid assets	Pensions + Illiquid assets	Financial literacy	Retirement security	Retirement advice	Financial advice	Information exposure	Log(Savings)	Savings to income	Saving for old age	Stocks	Real estate	Age	Male	Household income	
Defined contributions	1.00																						
Entrant post Auto-Enrolment	0.05	1.00																					
Retirement literacy	0.18*	-0.03	1.00																				
Pension only	-0.02	-0.03	-0.06*	1.00																			
State pension	-0.08*	0.01	-0.11*	0.70*	1.00																		
Pensions + Other	0.03	0.01	0.01	-0.17*	-0.12*	1.00																	
Pensions + Investments	0.18*	-0.07*	0.16*	-0.48*	-0.34*	-0.23*	1.00																
Pensions + Liquid assets	0.17*	-0.05	0.16*	-0.44*	-0.31*	-0.21*	0.90*	1.00															
Pensions + Illiquid assets	0.12*	-0.07*	0.12*	-0.25*	-0.18*	-0.12*	0.52*	0.29*	1.00														
Financial literacy	0.17*	-0.14*	0.26*	-0.05	-0.09*	0.02	0.29*	0.26*	0.17*	1.00													
Retirement security	0.10*	-0.01	0.28*	-0.05	-0.10*	0.01	0.22*	0.23*	0.10*	0.12*	1.00												
Retirement advice	0.2	0.01	0.12*	-0.14*	-0.10*	0.01	0.07*	0.07	0.07*	-0.04	0.25*	1.00											
Financial advice	-0.05	0.12*	0.06*	0.02	0.03	0.05	-0.13*	-0.13*	0.06*	-0.18*	0.24*	0.22*	1.00										
Information exposure	0.10*	0.04	0.16*	-0.12*	-0.14*	0.01	0.24*	0.23*	0.17*	0.20*	0.19*	0.15*	0.07*	1.00									
Log(Savings)	0.12*	-0.01	0.22*	-0.20*	-0.19*	-0.06*	0.33*	0.34*	0.17*	0.21*	0.36*	0.13*	-0.01	0.18*	1.00								
Savings to income	-0.03	-0.11*	0.06*	-0.14*	-0.12*	-0.07*	0.22*	0.21*	0.12*	0.09*	0.18*	0.03	0.11*	0.06*	0.56*	1.00							
Saving for old age	0.13*	-0.02	0.15*	-0.50*	-0.35*	-0.24*	0.77*	0.88*	0.23*	0.23*	0.24*	0.09*	-0.08*	0.22*	0.37*	0.21*	1.00						
Stocks	0.08*	-0.07*	0.17*	-0.16*	-0.12*	-0.06*	0.25*	0.26*	0.13*	0.16*	0.25*	0.17*	-0.01	0.23*	0.27*	0.17*	0.27*	1.00					
Real estate	0.11*	-0.06*	0.12*	-0.27*	-0.19*	-0.13*	0.43*	0.23*	0.92*	0.13*	0.10*	0.11*	-0.02	0.16*	0.18*	0.12*	0.20*	0.16*	1.00				
Age	0.01	-0.64*	0.07*	0.10*	0.03	0.03	0.14*	0.10*	0.12*	0.21*	0.08*	0.01	-0.16*	-0.03	0.08*	0.17*	0.03	0.10*	0.09*	1.00			
Male	0.01	-2.00	0.16*	0.01	-0.02	-0.01	0.01	0.02	-0.04	0.07*	0.21*	0.13*	0.13*	0.04	0.09*	0.04	0.04	0.10*	-1.00	0.01	1.00		
Household income	0.16*	0.02	0.23*	-0.08*	-7.00	0.03	0.16*	0.17*	0.11*	0.20*	0.29*	0.11*	0.06*	0.16*	0.31*	-0.24*	0.18*	0.24*	0.09*	0.02	0.11*	1.00	

Appendix Table 3

Pension plans and household financial behaviour in the United Kingdom – Instrumental variables IV models (DC) with Heckman correction for pension plan participation

This table shows the estimation results for the rest of the dependent variables on retirement finances. Column 1 shows the estimation results on the logarithm of the amount of savings. Column 2 continues with the effects on the ratio of savings to income while column 3 shows the estimates on saving for old age, owning stocks or have made other real estate investments for retirements respectively. All regressions are instrumental variables IV linear regressions with robust standard errors in parentheses, include the Inverse Mills ratio for the Heckman correction and region (12) fixed effects. The results are weighted at the population level. The asterisks denote the following levels of significance: *** : <0.01, ** : <0.05, * : <0.1.

	<i>Log(Savings)</i>	<i>Savings to income</i>	<i>Saving for old age</i>	<i>Stocks</i>	<i>Real estate</i>
	(1)	(2)	(3)	(4)	(5)
Defined Contributions Plan	3.214*** [0.651]	0.148*** [0.046]	0.287*** [0.107]	0.198** [0.078]	0.223** [0.089]
Inverse Mills Ratio	-0.136 [0.144]	-0.015 [0.010]	-0.045** [0.020]	-0.027* [0.014]	-0.037** [0.017]
Age	0.006 [0.008]	0.003*** [0.001]	0.001 [0.001]	0.002** [0.001]	0.001 [0.001]
Male	0.012 [0.149]	0.006 [0.010]	0.006 [0.022]	0.030* [0.016]	-0.039** [0.018]
Present orientation	-0.328*** [0.029]	-0.021*** [0.002]	-0.033*** [0.004]	-0.013*** [0.003]	-0.004 [0.004]
Education: Postgraduate	1.500*** [0.336]	0.118*** [0.023]	0.188*** [0.045]	0.04 [0.032]	0.046 [0.037]
-"-: Undergraduate	1.115*** [0.337]	0.083*** [0.024]	0.243*** [0.044]	0.022 [0.031]	0.062* [0.037]
-"-: Vocational	0.632** [0.305]	0.052** [0.021]	0.116*** [0.038]	0.016 [0.027]	0.036 [0.031]
-"-: Secondary	0.918*** [0.330]	0.067*** [0.022]	0.139*** [0.041]	0.016 [0.029]	0.041 [0.033]
-"-: Primary	0.725** [0.307]	0.049** [0.021]	0.121*** [0.036]	-0.041* [0.022]	-0.01 [0.029]
-"-: None/Incomplete	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
White	0.059 [0.243]	0.029 [0.018]	-0.013 [0.038]	-0.079*** [0.029]	-0.083*** [0.032]
Marital status: Single	0.189 [0.190]	0.018 [0.013]	0.066** [0.027]	-0.002 [0.019]	0.001 [0.024]
-"-: Married	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
-"-: Widowed/Divorced	-0.066 [0.287]	-0.041* [0.022]	-0.02 [0.038]	0.007 [0.026]	-0.003 [0.034]
Number of children	-0.084 [0.088]	-0.006 [0.007]	-0.012 [0.012]	-0.004 [0.008]	-0.001 [0.010]
Log(household income)	2.977* [1.627]	-0.106 [0.119]	0.446* [0.244]	0.549*** [0.155]	0.023 [0.176]
Log(household income) ²	-0.533** [0.235]	-0.004 [0.017]	-0.068* [0.035]	-0.086*** [0.023]	-0.004 [0.026]
Log(household income) ³	0.027*** [0.010]	0.001 [0.001]	0.003** [0.002]	0.004*** [0.001]	0.001 [0.001]
Home ownership: outright	1.886*** [0.188]	0.150*** [0.014]	0.100*** [0.030]	0.114*** [0.022]	0.129*** [0.023]
-"-: Mortgage	0.606*** [0.194]	0.033** [0.014]	0.038 [0.028]	-0.014 [0.017]	0.172*** [0.022]
-"-: None	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
Urbanity: Large city	0.192 [0.174]	0.014 [0.012]	0.008 [0.026]	-0.009 [0.017]	0.011 [0.021]

Table continued from the last page

	(1)	(2)	(3)	(4)	(5)
-": Small city/suburbs	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
-": Village	-0.144 [0.238]	-0.002 [0.016]	0.026 [0.034]	0.013 [0.024]	0.025 [0.031]
<i>% DC effect</i>	46.3%	53.7%	68.8%	156.0%	126.0%
<i>Predicted probability</i>	6.9477	0.2747	0.4175	0.1266	0.1768
<i>No. of Observations</i>	4,082	4,082	4,082	4,082	4,082

Appendix Table 4

Pension plans and household financial behaviour in the United Kingdom – Endogenous treatment effects models (DC) without Heckman correction for pension plan participation

This table shows the estimation results for the rest of the dependent variables on retirement finances. Column 1 shows the estimation results on the logarithm of the amount of savings. Column 2 continues with the effects on the ratio of savings to income, while column 3 shows the estimates on saving for old age, owning stocks or have made other real estate investments for retirements respectively. All regressions are maximum likelihood treatment regressions with robust standard errors in parentheses and include region (12) fixed effects. The results are weighted in the population. The asterisks denote the following levels of significance: ***: <0.01, **: <0.05, *: <0.1.

	<i>Log(Savings)</i>	<i>Savings to income</i>	<i>Saving for old age</i>	<i>Stocks</i>	<i>Real estate</i>
	(1)	(2)	(3)	(4)	(5)
Defined Contributions Plan	3.227*** [0.299]	0.125*** [0.047]	0.433 [0.292]	0.216*** [0.053]	0.194* [0.100]
Age	0.021*** [0.008]	0.003*** [0.001]	0.003* [0.002]	0.003*** [0.001]	0.002 [0.001]
Male	-0.051 [0.184]	-0.002 [0.009]	-0.019 [0.033]	0.036** [0.018]	-0.050* [0.030]
Present orientation	-0.347*** [0.036]	-0.022*** [0.002]	-0.028*** [0.007]	-0.020*** [0.004]	-0.002 [0.006]
Education: Postgraduate	0.677** [0.298]	0.081*** [0.017]	0.196*** [0.057]	0.05 [0.041]	0.049 [0.056]
-": Undergraduate	0.348 [0.369]	0.043* [0.023]	0.246*** [0.055]	0.047 [0.056]	0.042 [0.066]
-": Vocational	-0.471 [0.419]	-0.009 [0.020]	0.089 [0.078]	0.038 [0.051]	-0.004 [0.061]
-": Secondary	-0.284 [0.534]	-0.015 [0.029]	0.101* [0.057]	0.017 [0.048]	0.012 [0.048]
-": Primary	-0.48 [0.397]	-0.01 [0.026]	0.089 [0.081]	-0.045 [0.045]	-0.043 [0.053]
-": None/Incomplete	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
White	0.426 [0.380]	0.041 [0.036]	-0.012 [0.038]	-0.133*** [0.046]	-0.097** [0.043]
Marital status: Single	0.137 [0.355]	0.016 [0.014]	0.068* [0.038]	-0.006 [0.022]	0.028 [0.031]
-": Married	0.426	0.041	-0.012	-0.133***	-0.097**
-": Widowed/Divorced	-0.254 [0.320]	-0.037* [0.020]	-0.005 [0.063]	0.015 [0.038]	0.036 [0.038]
Number of children	-0.163 [0.150]	-0.012 [0.008]	-0.016 [0.026]	-0.009 [0.015]	0.007 [0.015]
Log(household income)	1.175 [1.860]	-0.187 [0.220]	0.225 [0.436]	0.833*** [0.260]	0.001 [0.228]
Log(household income) ²	-0.278 [0.260]	0.007 [0.031]	-0.039 [0.061]	-0.128*** [0.038]	-0.003 [0.031]
Log(household income) ³	0.017 [0.011]	0.001 [0.001]	0.002 [0.003]	0.006*** [0.002]	0.001 [0.001]
Home ownership: outright	1.988*** [0.164]	0.162*** [0.015]	0.182*** [0.043]	0.126*** [0.022]	0.173*** [0.037]
-": Mortgage	0.655*** [0.248]	0.036** [0.014]	0.081* [0.047]	0.004 [0.019]	0.232*** [0.025]
-": None	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
Labour status: Employee	0.201 [0.320]	0.012 [0.025]	-0.118* [0.060]	-0.054 [0.047]	-0.06 [0.045]
“-“: Self-employed	0.693 [0.578]	0.039 [0.033]	-0.079 [0.095]	0.008 [0.054]	-0.007 [0.071]

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	(1)	(2)	(3)	(4)	(5)
“-“: Unemployed	-1.747** [0.752]	-0.063 [0.041]	-0.152 [0.096]	-0.149*** [0.043]	-0.09 [0.060]
“-“: Homemaker	-0.47 [0.640]	-0.032 [0.047]	-0.065 [0.106]	-0.093* [0.052]	-0.037 [0.069]
“-“: Student	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
Urbanity: Large city	-0.005 [0.171]	-0.004 [0.009]	-0.015 [0.036]	-0.028 [0.030]	0.005 [0.041]
"-": Small city/suburbs	{Ref.}	{Ref.}	{Ref.}	{Ref.}	{Ref.}
"-": Village	-0.435 [0.364]	-0.012 [0.017]	0.018 [0.059]	0.011 [0.039]	0.036 [0.043]
<i>% DC effect</i>	<i>42.3%</i>	<i>41.9%</i>	<i>89.1%</i>	<i>132.3%</i>	<i>87.4%</i>
<i>Predicted probability</i>	<i>7.6282</i>	<i>0.2987</i>	<i>0.4865</i>	<i>0.1634</i>	<i>0.2223</i>
<i>No. of Observations</i>	<i>2,554</i>	<i>2,554</i>	<i>2,554</i>	<i>2,554</i>	<i>2,554</i>

Appendix Table 5

Instrument-validity tests

This table shows the three instrument validity tests for under identification, weak identification and over-identification equivalent to the regressions in *Appendix Table 3*. The F-test represents the F-test of excluded instruments. The null hypothesis in that case presumes that the excluded instruments have no explanatory power over the outcome variable and should be excluded from the model. The rejection of the null hypothesis is the appropriate outcome. The Sargan and Basmann's tests test the null hypothesis that both the instruments are appropriate instrumental variables for the specifications. The acceptance of the null hypothesis equals to instrumental variables validity. The estimate presents the Chi-squared value, followed by its P-value in the fractions below. The statistical significance in the Kleibergen-Paap LM statistics interprets in the rejection of the null hypothesis for weak identification. For the test for weak identification, the Kleibergen-Paap LM test should be compared to the Stock-Yogo weak ID critical value and when greater in value it suggests the rejection of the hypothesis for weak identification. Finally, the lack of statistical significance in the Hansen J statistic for over-identification shows the rejection of the hypothesis for over-identification. When each instrument is used separately, the Hansen J statistics is zero as the equation is exactly identified. The asterisks denote the following levels of significance: *** : <0.01, ** : <0.05, * : <0.1.

	Log (Savings)	Savings to income	Saving for old age	Stocks	Real estate
	(1)	(2)	(3)	(4)	(5)
Panel A: Both instruments					
F-test	46.69***	46.69***	46.69***	46.69***	46.69***
Sargan's test	0.030	0.836	3.693	4.438	1.487
	[0.863]	[0.360]	[0.055]	[0.035]	[0.223]
Basmann's test	0.029	0.830	3.666	4.406	1.475
	[0.864]	[0.362]	[0.056]	[0.0359]	[0.225]
Under-identification test (Kleibergen-Paap LM statistic)	86.700***	86.700***	86.700***	86.700***	86.700***
Weak identification test (Cragg-Donald Wald F statistic)	98.621	98.621	98.621	98.621	98.621
Stock-Yogo weak ID test critical values	19.930	19.930	19.930	19.930	19.930
Hansen J statistic	0.019	0.535	1.901	2.656	0.789
Panel B: Entrant post auto-enrolment					
Under-identification test (Kleibergen-Paap LM statistic)	8.530***	8.530***	8.530***	8.530***	8.530***
Weak identification test (Cragg-Donald Wald F statistic)	15.360	15.360	15.360	15.360	15.360
Stock-Yogo weak ID test critical values	16.38	16.38	16.38	16.38	16.38
Hansen J statistic	–	–	–	–	–
Panel C: Retirement literacy					
Under-identification test (Kleibergen-Paap LM statistic)	80.512***	80.512***	80.512***	80.512***	80.512***
Weak identification test (Cragg-Donald Wald F statistic)	182.779	182.779	182.779	182.779	182.779
Stock-Yogo weak ID test critical values	16.38	16.38	16.38	16.38	16.38
Hansen J statistic	–	–	–	–	–

