Declining Defined Benefit Plan Inclusion and the Impact on Savings and Retirement Decisions*

Rosemary Kaiser, Xiaohui Sun, and Yang Xuan

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Abstract

The last thirty years have seen a dramatic transition from traditional defined benefit retirement plans to defined contribution plans in the United States. To what extent has this transformation influenced the decline in retirement beyond age 65 and individuals' retirement savings decisions? We empirically document differences in retirement timing by retirement plan type and construct a model where enrollment in different plan types influences endogenous savings and retirement decisions. The model replicates differences in savings and retirement timing observed in the data. The model estimates that the shift towards defined contribution plans alone generated roughly 92% of the decline in retirement among individuals age 65+ observed in the data since the early 1990s. A decomposition reveals that defined benefit plans induce earlier retirement mainly by alleviating the risk associated with an uncertain planning horizon (life expectancy). In contrast, their role in reducing risk associated with uncertain investment returns is less impactful on retirement timing decisions.

JEL classification: E21, E24, J26, J32
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*Kaiser: Department of Economics, Rutgers University, 75 Hamilton St, New Brunswick, NJ 08901, USA., (email: r.kaiser@rutgers.edu). Sun: Department of Economics, Rutgers University, 75 Hamilton St, New Brunswick, NJ 08901, USA., (email: xiaohui.sun@rutgers.edu). Xuan: Department of Economics and Finance, Louisiana State University-Shreveport, 1 University Pl, Shreveport, LA 71115, USA., (email: xuanyang716@gmail.com).

1 Introduction

The shift from defined benefit (DB) to defined contribution (DC) plans in the U.S. has given individuals more control over their savings behavior while also exposing them to additional sources of risk. While DB plans typically guarantee payments for the life of the plan holder, and sometimes even for the life of their spouse, DC plans allow individuals to save for a retirement where the length of retirement is unknown due to uncertainty regarding the timing of death. How much has this shift contributed to the rise in labor force participation past age 65 and how has it influenced wealth and savings for the purpose of retirement?

DC plans grew quickly in popularity following the Revenue Act of 1978 which added Section 401(k) to the Internal Revenue Code[1], introducing a provision that allowed employees to defer a portion of their wages into retirement savings accounts on a pre-tax basis.[2] The introduction of 401(k) plans marked a significant shift in retirement planning, moving away from employer-funded defined benefit plans (like traditional pensions) toward defined contribution plans (like 401(k)s). From the early 1990's the percentage of individuals age 50+ with DC plans rose from under 20% to nearly 45%, making DC plans the most prominent type of retirement plan.[3]

At the same time as the shift towards DC plans, we document an almost 8 percentage point decline in the fraction of individuals age 65+ who are retired. To understand how different retirement plans might influence savings and retirement behavior, it is worth noting two major sources of uncertainty individuals face when planning for retirement. First, there is uncertainty regarding the planning horizon as agents may live to a very old terminal age but face uncertainty regarding exactly how long they will live. Second, there are uncertain returns to private investments and investments made in DC plans.

When studying how different retirement plans affect savings and retirement behavior, it is important to understand which types of uncertainty apply to each plan. Only those with a defined benefit (DB) plan have a feature that helps reduce the risk of an uncertain lifespan, as the DB plan guarantees fixed payments for life. People without a retirement plan, or those with a DC or hybrid plan[4], need to manage a pool of resources across an uncertain lifespan. The second type of risk is uncertain returns on investments, which affects all individuals making private investments. However, this risk is especially

[1]Revenue Act of 1978, Pub. L. No. 95-600, 92 Stat. 2763, 2785 (Nov. 6, 1978)

[2]While the Revenue Act of 1978 did not explicitly create 401(k) plans as we know them today, it laid the legal foundation that allowed these plans to emerge. In 1980, Ted Benna, owner of Pennsylvania benefits consulting company The Johnson Companies, recognized the potential of Section 401(k) to create a formalized retirement savings vehicle. He proposed and implemented the first 401(k) plan, which allowed employees to make pre-tax contributions with matching contributions from employers (Kujawa, 2012; U.S. Department of Labor, Employee Benefits Security Administration, 2007).

[3]Source: Health and Retirement Study (HRS), see Figure 1.

[4]Examples of hybrid plans include combination plans and cash balance plans (see Table 1). Section 3 will outline each type of retirement plan and additional details associated with these plans.

significant for those without a retirement plan or with a DC plan, as they rely more on potentially risky investments to fund their retirement.

To begin our analysis of how different risk exposures may affect retirement and savings decisions as the economy transitions towards DC plans, we use detailed panel data from the Health and Retirement Study (HRS) to document differences in retirement timing by plan type. We find that after controlling for detailed household, asset, occupation, health, and other characteristics, participants in DC plans are consistently less likely to retire than those with a DB plan at each year in their 60s. We then use the data to predict the final retirement age for participants by retirement plan. To address potential endogeneity, retirement plan dummies are instrumented with union status, pre-retirement occupation, and industry. The results indicate that participants enrolled in DC plans tend to have significantly higher predicted retirement ages compared to those in DB plans on average.[5]

Next, we construct a life-cycle model where enrollment in different plan types influences endogenous savings and retirement timing decisions. Agents in the model could live to an old terminal age but face an age-dependent death probability each period. Additionally, while all individuals can save in one-period bonds, individual investments and investments made in DC plans are subject to an uncertain rate of return. Retirement plans in the model are structured to mimic the mechanisms of true retirement plans as closely as possible, and all agents are eligible to receive Social Security income at retirement from the government. Upon entering the model, agents are exogenously enrolled in DC, DB, hybrid, or no retirement plan at rates that mimic the data. Those in DC and hybrid plans receive an employer contribution to their savings each period that they are employed. Employer contributions in DC plans are subject to an uncertain rate of return, while contributions in hybrid plans earn a risk-free rate of return (mimicking cash balance plans). In contrast, individuals enrolled in DB plans are eligible to receive a fixed benefit when retired for the remainder of their lives after reaching retirement age. The model replicates savings behavior and differences in retirement timing observed in the data.

We use our model to estimate the effects of the shift from DB to DC plans observed in the HRS data from 1992 through. In our model, the shift towards DC plans alone generates 91.9% of the decline in retirement among individuals age 65+ observed in the data since the early 1990s. We find that individuals enrolled in DC plans tend to accumulate significantly more private wealth by age 65, on average, compared to those in DB plans, who are less dependent on individually managed assets for their retirement. However, although those in DC plans accumulate more wealth by age 65, they consume a larger portion of their assets during retirement. By age 90, individuals with DC plans

[5]To address concerns that individuals with different preferences regarding their retirement timing might seek out different retirement plan types, we document that enrollment in DB plans is closely tied to differences in unionization status (see also Gustman and Steinmeier, 1992; Mishel and Walters, 2003). We use this as an instrument when running our second analysis in Section 3.

have lower average wealth, having depleted a greater share of their savings in retirement. Overall, the movement towards DC plans and away from DB plans increases the average retirement age and lowers total welfare.

Finally, we use the model to assess how greater exposure to each of the two main sources of risk associated with retirement planning contributes to our counterfactual results. To do this, we consider the same counterfactual movement away from DB and towards DC plans after first removing uncertainty regarding the planning horizon and then removing uncertainty in the return on investments. We find that the majority (62%) of the estimated decrease in the percentage of the population retired at age 65+ following the movement towards DC plans is driven by these plans exposing agents to uncertainty regarding the length of time they may spend in retirement.

The remainder of this paper is outlined as follows: Section 2 discusses the related literature and the contribution of this paper, Section 3 discusses motivating data and empirical observations, Section 4 presents the model, Section 5 presents model calibration and counterfactual results, and Section 6 concludes.

2 Related Literature

This paper contributes to the discussion regarding how variations in retirement plans influence retirement timing. Early work focuses on how variations among DB plans affect retirement decisions. Among this early work, Stock and Wise (1990) emphasize that DB plans which offer an "option value", which is a large retirement bonus received after a regulated early retirement age, incentivizes older workers to continue working until the regulated retirement age but leave the workforce right after reaching that age. This paper focuses on explaining why DB plans often induce a jump in the retirement rate at specific ages. Subsequent work by Samwick (1998) shows empirically that extended coverage of DB plans accounts for one-fourth of the decline in the labor market participation rate in the postwar period.

With the evolution of the retirement benefit structure, more recent work compares the impact of DB plans relative to DC plans on retirement timing with empirical approaches. Munnell et al. (2003) use the first wave of HRS responses to predict that otherwise identical individuals retire about eight months earlier with DB coverage than with DC coverage. Later, with additional data, Munnell et al. (2004) show that DB plan pensions wealth reduces the expected retirement age by 0.6 years, while the incentive structure of DB plans lower the expected age by another 1.1 years. Similarly, with HRS data, Friedberg and Webb (2005) find that the lack of age-related incentives in DC plans delays workers' retirement by about 2 years. Finally, using the Retirement Confidence Survey of College and University Faculty dataset, (Manchester, 2010), finds among college and university faculty the structure of DC plans directly increase expected retirement age by

up to one year relative to DB plans. Relative to most of the existing empirical work on this subject, our paper takes an innovative approach by using an instrumental variable method for the retirement plan dummies. This approach better addresses endogeneity concerns, specifically the possibility that individuals' retirement timing preferences may drive them to seek jobs with certain types of retirement plans.

This paper also connects to the literature that discusses the non-perfect substitution between retirement plan wealth, which includes both public and private retirement account savings, and private savings. Gustman and Steinmeier (1999) used detailed HRS data for a cohort of 51- to 61-year-olds born from 1931 to 1941 and showed that pension wealth accounted for around one quarter of total accumulated wealth. Taking advantage of the Italian pension reform of 1992, which substantially reduced pension wealth, Attanasio and Brugiavini (2003) applied a difference-in-differences approach to show that pension wealth is a substitute for private savings. However, the degree of substitution varies across different specifications. Following a similar spirit, Attanasio and Rohwedder (2003) investigated the impact on private savings induced by three major pension reforms in the U.K. in the 1970s and 1980s. They found that the earnings-related tier of the pension structure had a relatively high negative impact on private savings and the substitutability is age-dependent. These empirical findings are consistent with other studies that find negative but non-perfect substitution between pension wealth and private savings using data from the U.S. (Engelhardt and Kumar, 2011), 13 countries in Europe (Alessie et al., 2013), and Poland (Lachowska and Myck, 2018). Our model successfully replicates the savings behavior observed in these empirical studies. We find that with the shift from DB to DC plan, DC plan holders tend to accumulate significantly more private wealth than DB plan holders by age 65, though they consume most of the assets during retirement and leave with lower average wealth by age 90.

Theoretically, our model builds off of previous life-cycle models of savings and retirement decisions, including French (2005), Blau (2008), De Nardi, French and Jones (2010), French and Jones (2011), and Fan, Seshadri, and Taber (2024). Our paper adds to this literature by incorporating differences in retirement plan types to allow us to study how the transition from DB to DC plans has influenced aggregate retirement timing decisions.

With the goal of studying changes in the provision of different retirement plan types, our paper is related to Samwick (1998), which aimed to study the effects of differences among DB plans with a simple model. More recently, Daminato and Padula (2024) constructed a model to study how Italian reforms in the early 1990s influenced retirement timing. They focus on comparing the pre-reform regime, assumed to have a fixed exogenous retirement age and only pension wealth, with the post-reform regime, which allows for an endogenous retirement choice within an age window. They focus on understanding how social security wealth interacts with these two regimes and estimating the distributional impacts of the reforms on different age groups. Our paper is perhaps most

closely related to Heiland and Li (2012), which investigated how the shift from DB to DC plans' impacted senior labor force participation in the U.S. from 1977 to 2010. While Heiland and Li (2012) emphasize that age-related wealth accrual schedules incentivize workers with DB plans to choose to retire earlier than those with DC plans, and incorporate these plan features into a model otherwise based on French (2005), we introduce a model that allows us to consider how different retirement plans interact with an important source of risk not present in French (2005). Specifically, our model setup allows us to evaluate different retirement plans based on how their structure exposes individuals to planning horizon risk (the risk associated with allocating resources over an unknown length of retirement, as agents do now know when they will die and exit the model), a risk which is present in French (2005). However, our model also incorporates uncertain returns to investments for individual and DB plan investments, an element not present in the previous literature. With the model calibrated to the U.S. data, we quantify the impacts of increasing DC plan coverages on retirement age and decompose the effects of these two major risk sources.

3 Empirical Evidence

This section presents four empirical observations that will motivate the model constructed in Section 4. First, there has been a significant transition from DB retirement plans towards DC plans among individuals age 50 and older since the early 1990s. Second, individuals in DB plans are more likely to transition into retirement relative to those in DC plans, after controlling for observables such as age, household characteristics, wealth, health, etc. Third, participants enrolled in DC plans tend to have significantly higher predicted retirement ages compared to those in DB plans. Finally, at the same time as the shift towards DC plans, there was an almost 8 percentage point decline in the fraction of individuals age 65 or older who were retired.

3.1 Data Description and Retirement Plan Categorization

The primary dataset used in this section is the Health and Retirement Study (HRS) spanning 1992 to 2020. The HRS is a longitudinal household survey collecting participants' retirement plan and employment information.[6] Participants in the study include individuals over age 50 and their spouses, regardless of the spouse's age. Interviews began in 1992 and were conducted biannually, covering seven cohorts with participants entering and exiting in each round. The HRS dataset includes detailed information on individual demographics, employment history, income sources, and social security income, along with detailed retirement plan enrollment information from current jobs.

[6]We use RAND HRS Longitudinal File 2020 (V2).

The original HRS dataset contains 280,343 unique individuals with valid responses in surveys. From this dataset, we exclude respondents missing key demographic information, such as age, race, or census region of residence in each wave. Since our project focuses on how retirement plan enrollment affects retirement decisions, we also remove participants who were already retired before their first interview. Additionally, participants must have valid data on labor force participation status, retirement plans for their current main job, retirement status, health status, and union coverage. During the interviews, individuals are asked to report detailed retirement plans for up to four current jobs, ranked by importance. In this study, we focus solely on each individual's current main job and categorize the corresponding retirement plans into four broad types: no plan, Defined Benefit (DB) plan, Defined Contribution (DC) plan, and Hybrid plan. *Table 1* provides a summary of the detailed plans reported in the HRS and the four broad categories that we sort them into. While it is possible for participants to change their retirement plans

Table 1: Categorization of Detailed Retirement Plans

Types of Retirement Plans	Detailed Types
No Plan	No retired plans or only health plan mentioned
Defined Benefit Plan	Defined benefit plan
Defined Contribution Plan	Defined contribution plan; 401k plan; 401a plan; 403b plan; 457 plan; thrift/savings plan (tsp); profit-sharing plan; employee stock ownership; money purchase plan; employee stock purchase; sep or simple plan
Hybrid	Combination plan; cash balance plan

over time, over 72% of participants never switch plans during the years they work.[7]

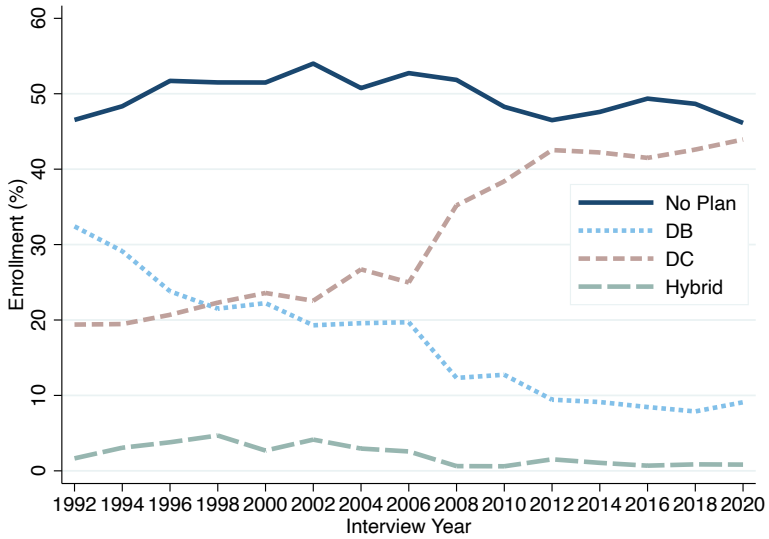
Finally, there are no missing values for marital status (ever married or never married), household wealth, and capital income for each participant. *Table 8* in *Appendix A.1* outlines the sample selection process step by step, including a summary of the remaining individuals and observations after each step. The sample includes 33,036 unique participants and 233,095 observations, representing over 83% of the original dataset. Our sample comprises nearly equal proportions of females and males, with the majority being White or Caucasian. As the HRS survey targets individuals over age 50 and their spouses, over half have a high school education or less, while about 23% have attended some college. Additionally, over 92% have been married at least once, highlighting the need to consider family or household effects when analyzing the impact of retirement plan choices on savings and retirement decisions. *Table 9* in *Appendix A.2* provides a detailed description of the sample characteristics.

Next, *Figure 1* displays retirement plan inclusion over time for participants in our

[7] *Appendix A.2* provides further information regarding the frequency of retirement plan switches in the data.

sample. This figure displays our first motivating observation, showing that there was a significant transition from DB into DC retirement plans since the early 1990s. The

Figure 1: Retirement Plans of Current Main Job in Each Interview Year



Notes: Data displayed is from the Health and Retirement Study (HRS). The categorization of possible detailed retirement plan types into defined benefit (DB), defined contribution (DC), or hybrid categories is described in *Table 1*.

proportions of participants with no retirement plan or a hybrid plan from their main job remained relatively stable across the years observed. However, we observe that the share of participants enrolled in defined contribution plans increased by more that 20 percentage points from the early 1990s to 2020. Along this same time-frame, the share of participants enrolled in defined benefit plans decreased by more than 20 percentage points.

3.2 Differences in Retirement Timing by Plan Type

We first examine the relationship between retirement plan type and the probability of transitioning from employment to retirement. Using a logistic regression, we estimate the employment to retirement transition probability for individuals aged 60 to 69.

Table 2 summarizes the regression results for transitions between employment and retirement among participants aged 60 to 69 by retirement plan types. The regression accounts for occupation, industry, year, and residence location effects, which are controlled for but not reported in the table for brevity. The results reveal that enrollment in a DC plan, rather than the excluded comparison group of enrollment in a DB plan is associated with a lower probability of transitioning into retirement, controlling for age and other detailed characteristics.

Figure 2 illustrates the predicted probability of transitioning from employment to retirement for participants aged 60 to 69, categorized by retirement plan type at the

Table 2: Employment to Retirement Transitions Among Ages 60-69

	Estimates	S.E.
Retirement plans		
DC	**-0.410*** **	**(0.063)**
Hybrid	**-0.062**	**(0.132)**
Age	3.312***	(0.467)
Age squared	-0.025***	(0.004)
Hourly wage	0.004*	(0.002)
Hourly wage squared	0.000	(0.000)
Income from retirement plans	0.000**	(0.000)
Income from retirement plans squared	0.000	(0.000)
Income from social security retirement	0.000	(0.000)
Income from social security retirement squared	0.000	(0.000)
Household wealth (including house)	0.000	(0.000)
Female	0.165**	(0.071)
Constant	-108.638***	(14.854)
σ_u	0.003	25.489
ρ	0.000	0.047
Observations	7,859	

Notes: The table shows the results of a logistic regression using data from the Health and Retirement Study (HRS). The regression includes the participant's and spouse's self-reported health conditions, the participant's race, educational degree, occupation, industry, as well as region and year fixed effects. Robust standard errors are in parenthesis. Stars denote statistical significance $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

time of the decision. Panel (a) shows that participants enrolled in a hybrid plan are not significantly more likely to retire compared to those with a Defined Benefit (DB) plan.[8] In contrast, panel (b) indicates that participants with a defined contribution (DC) plan are consistently less likely to retire than those with a DB plan across all ages.

Next, we explore the predicted final retirement age for participants by retirement plan, using the following model:

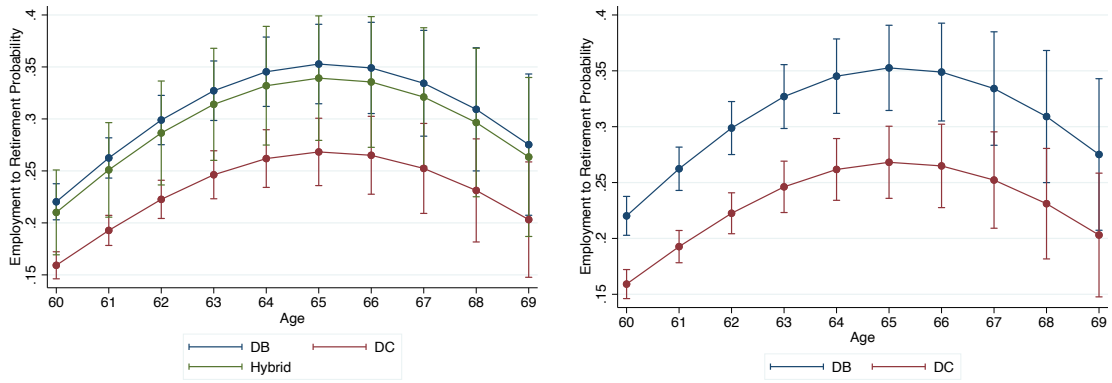
$$RetireAge_i = \alpha + \boldsymbol{\beta'}\boldsymbol{RetirePlan_i} + \boldsymbol{\gamma'}\boldsymbol{X_i} + \epsilon_i \tag{1}$$

where $RetireAge_i$ represents the final retirement age of individual i, $\boldsymbol{RetirePlan_i}$ includes dummy variables indicating three retirement plan types, and $\boldsymbol{X_i}$ is a vector of control variables, including household total wealth, pre-retirement wage and its squared term, and dummies for individual health status, gender, race, education, marital status, region, and retirement year. To address potential endogeneity concerns, we instrument retirement plan dummies with union status, pre-retirement occupation, and industry. The concern arises because individuals with varying retirement timing preferences might self-select into jobs that offer their preferred retirement plans, creating an endogeneity issue. In

[8]The large confidence interval for participants enrolled in hybrid plans is due to the small number of participants in this group.

Figure 2: Employment to Retirement Probability

(a) By Retirement Plans *(b) DB and DC only*



Notes: The figure shows predicted probability of entering retirement from employment at each age based on retirement plan type. The predicted probabilities are estimated using the results of the logistic regression using data from the Health and Retirement Study (HRS) displayed in Table 2.

Appendix B.2, we employ a difference-in-difference methodology to assess the effects of enacting Right-to-Work laws—which reduce union coverage—on Defined Benefit (DB) plan enrollment. Our findings indicate a notable decline in DB plan enrollment associated with the introduction of Right-to-Work laws and the associated decrease in union coverage. This supports the validity of union status as a strong instrument.[9]

Table 3: Predicted Retirement Age by Retirement Plans

	Predicted Age	95% Confidence Interval
DB	61.897***	[61.213, 62.581]
	(0.349)	
DC	65.991***	[64.801, 67.182]
	(0.607)	
Hybrid	73.613***	[58.775, 88.452]
	(7.751)	

Notes: The table presents the predicted retirement wages for participants enrolled in Defined Benefit (DB), Defined Contribution (DC), and Hybrid retirement plans, estimated using instrumental variable (IV) regression, based on data from the Health and Retirement Study (HRS) sample. The main regression model is specified in Equation (1). Robust standard errors are reported in parentheses. Statistical significance is indicated by asterisks: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 3 illustrates the predicted final retirement age for individuals with different retirement plans. The results indicate that participants enrolled in DC plans tend to have significantly higher predicted retirement ages compared to those in DB plans on average.

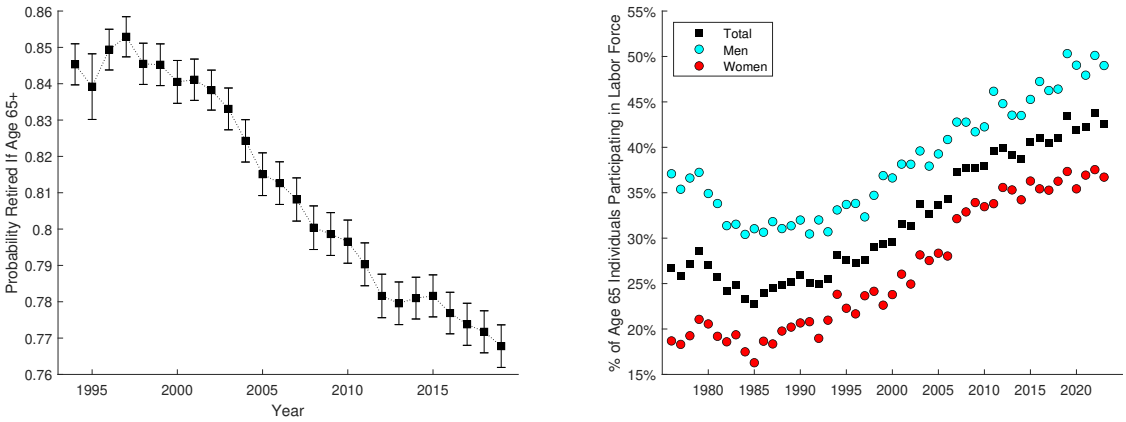
[9]Additionally, the first-stage F-statistics for these instruments indicate high significance (p-value close to 0), affirming their strength and relevance.

3.3 Decline in Retirement Among Age 65 and Older

Finally, we document our final motivating empirical observation, a decline in retirement among individuals age 65 and older. First, the left panel of *Figure 3* shows the probability of an individual reporting that they are retired if age 65 or older by year in the Current Population Survey (CPS). We see from the early 1990s the probability of retirement among this age group has declined by 7.76 percentage points.

Figure 3: Decrease in Retirement at Age 65

Probability of Retirement if Age 65+ *Age 65 Participation Rate*



Notes: Current Population Survey (CPS) data

With this initial observation, it is possible that the decline in retirement could have been brought about by demographic shifts. For example, a change in the age composition among the total population age 65 or older. To better control for any demographic shifts, we also plot the percentage of the population who are still participating in the labor force at exactly age 65 by gender in the right panel of the figure. Interestingly, there is a slight decrease in participation at age 65 from the late-1970s to the mid-1980s. Then, starting around the early 1990s there is a notable increase in participation at age 65 for both genders. In *Appendix B.1* we also show that the increase in participation persists when separately analyzing college graduates and non-graduates of either gender.

4 Model

The model introduced in this section aims to capture the main trade-offs associated with enrollment in different retirement plans. Agents can be enrolled in no plan, a defined benefit (DB) plan, a hybrid plan, or a defined contribution (DC) plan. Agents face two sources of uncertainty when planning for retirement. First, there is uncertainty regarding the planning horizon as agents may live to a very old terminal age but face uncertainty regarding exactly how long they will live. Second, there are uncertain returns to private investments and investments made in DC plans.

In understanding how different retirement plans influence savings and retirement behavior, it is crucial to note whether each source of uncertainty is present for individuals with each particular retirement plan. Only those with a DB plan have a mechanism that can alleviate the risk associated with an uncertain planning horizon, as the DB plan offers fixed payments for life. Those with no plan or with a DC or hybrid plan must instead allocate a pool of resources across an uncertain planning horizon. The second source of risk, uncertain returns to investments, is present for all agents who make private investments. However, the second source of risk is most significant for those with no retirement plan or a DC plan, who must rely more heavily on potentially risky investments to fund their retirement.

4.1 Model Environment

4.1.1 Setting

Time is discrete and continues forever, with each period in the model representing one quarter. Agents who populate the model may live to terminal age $\overline{a}$ but face a death probability dependent on age (a), $\nu(a)$. Each period, a unit mass of age 18 agents enters the model while a unit mass dies at various ages. An agent could be employed, unemployed, or retired in any period.[10]

Agents are heterogeneous in their age (a), current labor force status (employed, unemployed, or retired), level of assets (b), and retirement plan type (i_p). Income equals y when employed, and the unemployment benefit equals a fraction ϕ of employment income. Agents also draw their retirement plan type i_p when entering the model, with $i_p \in \{N \text{ (None)}, B \text{ (DB Plan)}, H \text{ (Hybrid)}, C \text{ (DC plan)}\}$.

4.1.2 Movements Between Employment States: Endogenous Retirement

Employed agents face exogenous job loss probability $\delta(a)$, while the probability of regaining employment if unemployed is $\eta(a)$. These probabilities depend on the agent's age a, as data displays significant differences over the life-cycle in these probabilities. While movements between employment and unemployment are exogenous, the choice to retire is endogenous. At the end of each period, agents decide to continue in employment or unemployment into the next period or to retire.

4.1.3 Consumption and Savings Decisions

Agents get utility $u(c, \ell)$ from consumption c and leisure ℓ. Let ℓ_P denote leisure enjoyed if participating in the labor force via employment or unemployment, and ℓ_R

[10]While the model introduced in this section makes no distinction between part-time and full-time employment (in other words, all employment is assumed to be full-time) *Appendix* **??** considers the same model where employed agents can choose to work either part-time or full-time.

denote leisure enjoyed in retirement. All individuals enter the model with zero assets and can save in one-period bonds[11]. However, individual investments and investments made in DC plans are subject to an uncertain rate of return r_r with $r_r = r_s + \epsilon$ with $\epsilon \sim \mathcal{N}(0, \sigma_\epsilon^2)$.

All agents can choose to save in one-period bonds offering a risky rate of return r_r that is unrealized at the time of investment, just as in reality, all individuals may make personal investments. Those in DC plans, however, get an extra payment of equal to fraction f_c of their employment income when employed invested into the risky asset from their employer (e.g., an employer contribution to a 401(k)).

Only those in DB and hybrid retirement plans can contribute a portion of their income in exchange for a certain outcome. Those with a DB plan receive payment $x_B(a, y)$ each period in retirement, while those with a hybrid plan have their employer contributions $f_c \times y$ invested at a safe interest rate r_s.[12] Finally, in retirement, all agents receive a benefit from the government γ_a that they can access at a certain age (representing social security benefits).

Finally, agents receive a utility value from leaving bequests (dying with positive asset values). This assumption is common in the literature (see Gourinchas and Parker (2002), De Nardi, French, and Jones (2010), Daminato and Padula (2024), among others) and will allow our model to more closely match savings behavior over the life-cycle and the observation that many individuals die with non-trivial positive levels of assets. Let $\zeta(b)$ denote the value of dying with assets b.

4.1.4 Timing

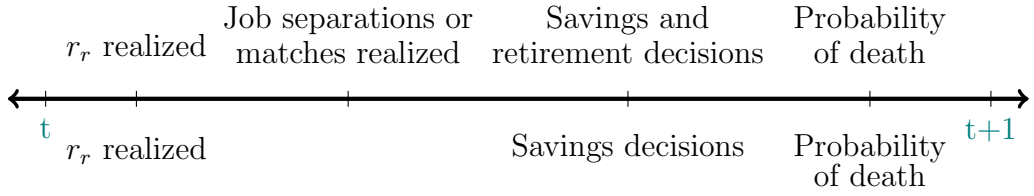
Figure 4 summarizes the timing of events in the model. At the beginning of each period, agents observe the actual risky rate of return r_r that they receive on the investments made in the last period. Notice that when making savings and retirement decisions in the current period, agents do not know the actual rate of return r_r that they will realize on their investments. After observing the realize value of r_r agents who are not retired could lose their job if they enter the period employed and could find a job if they enter the period unemployed. Then, agents then make their savings decisions. They decide how much to consume and save in the current period. Still, the level of assets available in the next period is uncertain and depends on the agent's savings and the next-period realization of r_r. At this time, individuals still in the labor force decide whether or not they want to remain in the labor force or retire in the next period. Finally, at the end of each period, all agents face an age-dependent probability of death $\nu(a)$.

[11]The model assumes only savings but no borrowing as in most of the related literature: French (2005), De Nardi, French, and Jones (2010), French and Jones (2011), and Heiland and Li (2012).

[12]In the model, this mimics cash-balance "hybrid" plans where individuals with these plans get access to a known amount of assets in retirement, and the amount is not subject to any uncertain rate of return or other source of risk.

Figure 4: Model Timing

Not Retired:



Retired:

4.2 Value Functions

Let $V_a^E(b, i_p)$ denote the value of employment for an age a individual who has assets b, and retirement plan i_p.

$$V_a^E(b, i_p) = \max_{s, R \in \{0,1\}} \{u(c, \ell_P) + \nu(a)\beta\mathbb{E}[\zeta(b'_E(s, i_p))] + R(1-\nu(a))\beta\mathbb{E}\left[V_{a+1}^R(b'_E(s, i_p), i_p)\right] \quad (2)$$
$$+ (1-R)(1-\nu(a))\beta\mathbb{E}\left[(1-\delta(a+1))V_{a+1}^E(b'_E(s, i_p), i_p) + \delta(a+1)V_{a+1}^U(b'_E(s, i_p), i_p)\right]\}$$

Agents choose how much to save s and whether to remain in the labor force or retire before the next period $R \in \{0, 1\}$. The budget constraint for the employed is as follows: consumption and savings equal the amount of assets the agent has b plus income y.

$$c + s = b + y \quad (3)$$

Agents choose how much to save s, but the amount of assets they end up with in the next period is subject to the risky rate of return r_r which is not observed until the start of the next period. Let $b'_E(s, i_p)$ denote realized assets in the next period given savings s made when employed with a retirement plan of type i_p. In addition to the individual's personal savings, those enrolled in a DC or hybrid plan also receive an employer contribution of amount $f_c \times y$ to savings. The employer contribution is invested at the risky rate of return for those in a DC plan, while agents with a hybrid retirement plan have their employer contribution invested at a guaranteed safe rate of return r_s.

$$b'_E(s, i_p) = (1 + r'_r)(s + yf_c(\mathbb{1}_{i_p=C})) + (1 + r_s)yf_c(\mathbb{1}_{i_p=H}) \quad (4)$$

After making savings and retirement decisions agents face probability $(1-\nu(a))$ of surviving into the next period. If the agent does not survive, they receive value $\mathbb{E}[\zeta(b'_E(s, i_p))]$, the expected utility value from the bequests they will leave. Employed workers who survive and who did not choose to retire then become unemployed with probability $\delta(a+1)$ and remain employed with probability $(1 - \delta(a+1))$.

Next, let $V_a^U(b, i_p)$ denote the value of unemployment for an age a individual who has assets b, and retirement plan i_p.

$$V_a^U(b, i_p) = \max_{s,R\in\{0,1\}} \big\{u(c, \ell_P) + \nu(a)\beta\mathbb{E}[\zeta(b'_U(s))] + R(1-\nu(a))\beta\mathbb{E}[V_{a+1}^R(b'_U(s), i_p)] \quad (5)$$
$$+(1-R)(1-\nu(a))\beta\mathbb{E}\left[(1-\eta(a+1))V_{a+1}^U(b'_U(s), i_p) + \eta(a+1)V_{a+1}^E(b'_U(s), i_p)\right]\big\}$$

Agents choose how much to save s and whether to remain in the labor force or retire before the next period $R \in \{0, 1\}$. The budget constraint for the unemployed is as follows.

$$c + s = b + y\phi \quad (6)$$

Unemployed agents receive unemployment income $y\phi$. Their consumption and savings equal their income plus their pool of existing assets. Let $b'_U(s)$ denote realized next-period assets given savings s when unemployed and realized next-period risky rate of return is r'_r.

$$b'_U(s) = (1 + r'_r)s \quad (7)$$

After making savings and retirement decisions these agents face probability $(1 - \nu(a))$ of surviving into the next period. Unemployed agents who survive and who did not choose to retire then become employed with probability $\eta(a + 1)$ and remain unemployed with probability $(1 - \eta(a + 1))$.

Finally, $V_a^R(b, i_p)$ denotes the value of retirement for an age a agent with assets b, and retirement plan i_p.

$$V_a^R(b, i_p) = \max_s \big\{u(c, \ell_R) + \nu(a)\beta\mathbb{E}\left[\zeta(b'_R(s))\right] + (1-\nu(a))\beta\mathbb{E}[V_{a+1}^R(b'_R(s), i_p)]\big\} \quad (8)$$

In retirement, the agent receives an age-dependent benefit from the government replacing γ_a of their employment income. Specifically, $\gamma_a = 0$ for all a values lower than the minimum age set by the government to receive this retirement benefit and $\gamma_a = \gamma$[13] for all ages a at and above the minimum age. Consumption plus savings equals the government retirement income plus the agent's existing pool of assets b. Additionally, if the agent has a DB plan ($i_p = B$), then they get income $x_B(a, y)$.

$$c + s = y\gamma_a + b + (\mathbb{1}_{i_p=B})x_B(a, y) \quad (9)$$

[13]We assume everyone has social security income after a certain age. Although some papers suggest that some employees do not participate in social security (Morrill and Westall, 2019; Kim et al., 2024), there have been studies show that the impact of social security benefits on average retirement age is very small (Dimond and Hausman, 1984; Samwick, 1998; Kim et al., 2024). Also, our main focus is to compare the impacts across DB and DC plans not on the social security benefit. So this assumption will not affect the main dynamics of the model.

In retirement, if agents save s, then their realized assets in the next period given realized next-period rate of return r'_r are as follows.

$$b'_R(s) = (1 + r'_r)s \tag{10}$$

At the end of each period, the agent faces age-dependent death probability $\nu(a)$.

Finally, the state of the economy can be summarized by $\psi = (m^E, m^U, m^R)$, where the first element of ψ is a function with $m^E(a, b, i_p)$ denoting the mass of individuals employed at age a with retirement plan i_p and assets b. The second element is a function $m^U(a, b, i_p)$ denoting the mass unemployed at age a with retirement plan i_p and accumulated assets b, and similarly, the final element is a function $m^R(a, b, i_p)$ denoting the mass of retired individuals with these characteristics.

4.3 Equilibrium

Definition 1: *A Recursive Equilibrium (RE) is given by the following.*

1. *Value functions* $\{V_a^E(b, i_p), V_a^U(b, i_p), V_a^R(b, i_p)\}$
2. Optimal savings policy functions $s_a^{E*}(b, i_p)$, $s_a^{U*}(b, i_p)$, $s_a^{R*}(b, i_p)$ and optimal retirement policy functions $R_a^{E*}(b, i_p)$, $R_a^{U*}(b, i_p)$ solve (2) and (5).
3. Transition probability functions determine the aggregate state of the economy $\psi = (m^E(a, b, i_p), m^U(a, b, i_p), m^R(a, b, i_p))$ and are consistent with the equilibrium optimal savings functions and optimal retirement policy functions (see *Appendix B.2*).

The transition probability functions follow directly from the timing assumptions of the model.

5 Results

5.1 Calibration

We solve the model introduced in Section 4 under the following assumption regarding the agents' utility function. If agents are employed or unemployed, they receive utility $u(c, \ell_P) = \log(c) + \ell_P$, while retired agents enjoy utility $u(c, \ell_R) = \log(c) + \ell_R$. Notice that when comparing the utility of labor force participation and retirement, what is relevant is the difference between leisure values $\ell_R - \ell_P$. It is for this reason that we normalize $\ell_P = 0$ and estimate the value of ℓ_R relative to this normalization. Following De Nardi, French, and Jones (2010), the value of bequests $\zeta(b)$ is derived from the agents' utility from consumption so that the value of leaving bequests b is $\zeta(b) = \zeta_c \log(b)$.

Table 4 lists the model parameters that we directly assign. β is the quarterly discount factor for which we choose a standard value corresponding to an annual 4% risk-free rate of return, with the quarterly risk-free rate of return $r_s = (1/\beta) - 1$. As previously discussed, we normalize $\ell_P = 0$ and will later estimate the value of ℓ_R. Similarly, we normalize income earned when employed $y = 1$, and will specify other income sources, such as social security income, based on the fraction of employment income that they replace on average. The remaining directly assigned parameter values are taken directly from the data. Values for the average unemployment insurance and social security replacement rates are taken from estimates provided from the U.S. Department of Labor[14] and the U.S. Social Security Administration[15] respectively. While employer contributions to DC plans can vary, we set f_c to reflect that the average employer contribution is 4.6% of employee income, as reported by Vanguard (2024). Similarly, while DB plan benefits can vary, we set the value of x_B to reflect the average private DB pension replacement rate for individuals with 30 years of plan participation and final earnings of $65,000 reported by Foster (1997).[16] The quarterly age-dependent unemployment-to-employment (UE) and employment-to-unemployment (EU) transition probabilities are estimated using CPS data, and these results are displayed in *Figure 5*.[17] The age-dependent death probabilities

Table 4: Directly Assigned Parameter Values

Parameter	Description	Value/Source
β	Quarterly discount factor	0.99 (Standard, 4% annual risk-free return)
ℓ_P	Leisure enjoyed in labor force	0 (Normalization)
y	Earnings in employment	1 (Normalization)
ϕ	Unemployment insurance replacement rate	0.4627 (Average from U.S. Department of Labor)
γ	Social security replacement rate	0.4 (Average from Social Security Admin.)
f_c	Employer DC/hybrid plan contribution	0.046 (Vanguard, 2024))
x_B	DB replacement rate	0.289 (Foster, 1997)
$\eta(a)$	Age-dependent UE probability	CPS estimate (*Figure 5*)
$\delta(a)$	Age-dependent EU probability	CPS estimate (*Figure 5*)
$\nu(a)$	Age-dependent death probability	Social Security Admin. Actuarial Life Table
$p_r(i_p)$	Pr. of drawing each retirement plan	*Figure 1*, 1992 Values

in the model are taken directly from the U.S. Social Security Administration's Actuarial

[14]The average unemployment insurance replacement rate is computed by the U.S. Department of Labor (see https://oui.doleta.gov/unemploy/ui_replacement_rates.asp) for various years. We use the average replacement rate over 1992-2020, corresponding with same time-frame for the data used in Section 3. We take the replacement rate computed by the DOL using their "Replacement Ratio 1" measure computed as the weighted average of the claimants' weekly benefit amount divided by the product of the claimants normal hourly wage and 40 hours per week, where ratios greater than or equal to 2 are excluded as outliers.

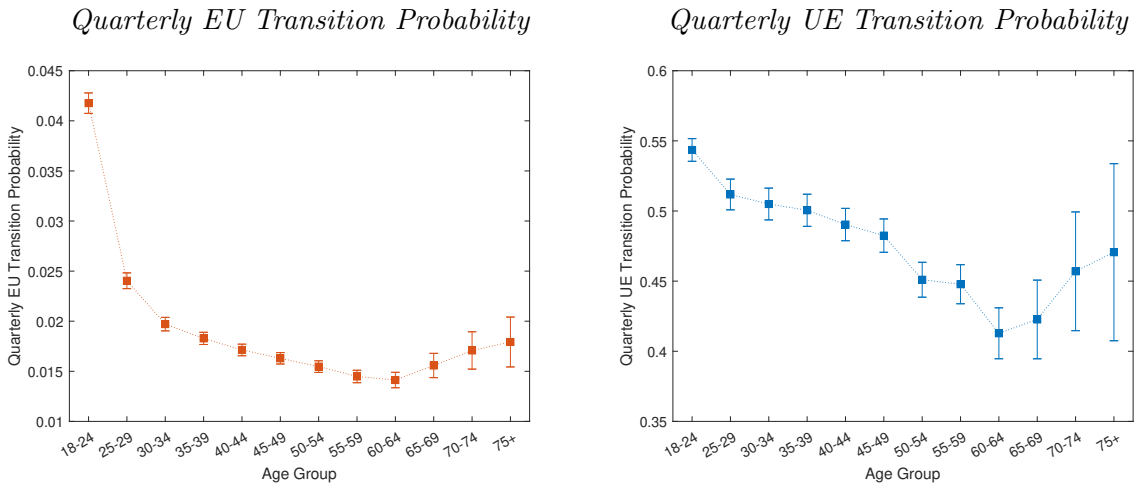
[15]While social security benefits vary by individuals' employment income, retirement age, and other factors, the U.S. Social Security Administration reports that "On average, Social Security will replace about 40% of your annual pre-retirement earnings" (SSA Publication No. 05-10706: https://www.ssa.gov/myaccount/assets/materials/workers-61-69.pdf).

[16]Foster (1997) reports that this replacement rate increases only slightly from 28.9% to 29.2% for individuals with final annual earnings of $35,000.

[17]The CPS data used spans 1992-2019 for consistency with Section 3 while excluding 2020, a year in which these transition probabilities where affected by abnormal circumstances.

Life Table[18] and adjusted to reflect quarterly probabilities. Finally, the probabilities of drawing each of the four retirements plans when entering the model are taken from our HRS estimates previously displayed in *Figure 1* for the year 1992, before the notable switch from DB towards DC plans.

Figure 5: Estimated Quarterly Transition Probabilities by Age from CPS



After assigning the model parameters listed in *Table 4*, we jointly calibrate the remaining parameters to align the model with relevant features of the data. *Table 5* displays the parameters in the model that are jointly calibrated, their estimated values, descriptions, and a comparison of the targeted data moments and corresponding model-generated moments. In calibrating the standard deviation σ_ϵ of shocks to the risky rate of return, we target the coefficient of variation of quarterly returns from the NASDAQ Composite Index over 1992-2020.[19] Next, the key parameter in the model driving the incentive to retire is the retirement leisure value ℓ_R. This parameter is calibrated targeting the percent of the population retired if age 65+ estimated from the Current Population Survey. Finally, the bequest value parameter ζ_c is an important parameter influencing incentives to spend vs. save in retirement. A higher ζ_c value increases agents' bequest motive and

Table 5: Jointly Calibrated Parameter Values

Parameter	Estimate	Targeted Moment	Data	Model
σ_ϵ	0.038100	Quarterly returns coefficient of variation	3.6945	3.6963
ℓ_R	0.731960	Percent retired if age 65+	78.16%	78.17%
ζ_c	5.137882	% Change median net worth 55-64 to 75+	-21.56%	-21.69%

results in agents consuming a smaller fraction of the savings built-up before retirement.

[18] https://www.ssa.gov/oact/STATS/table4c6.html

[19] NASDAQ OMX Group, NASDAQ Composite Index [NASDAQCOM], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NASDAQCOM.The estimate coefficient of variation does not notably change when excluding 2020 data.

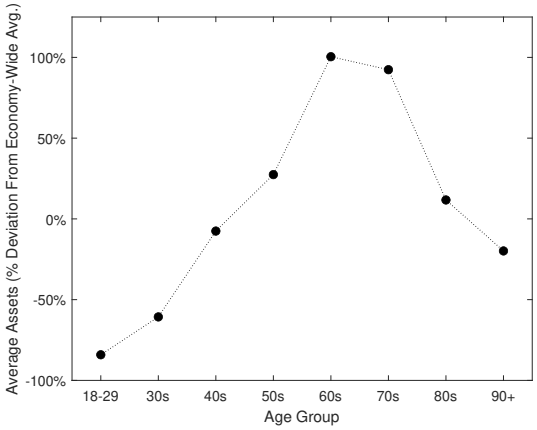
ζ_c therefore targets the percentage change in median net worth between ages 55-64 and age 75+ computed from the Survey of Consumer Finances.[20]

5.2 Model Dynamics

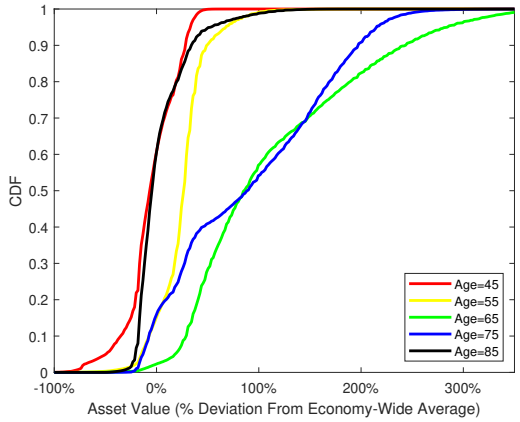
An important feature of the model is that agents accumulate assets for retirement as they age. The left panel of *Figure 6* shows that the average level of assets conditional on age increases significantly as individuals enter the model at age 18 until they reach their 60s. After entering their 60s many individuals will start to retire, where they will begin to consume some of their accumulated assets. Thus, we see average assets decline as individuals move from their 60s into their 80s and beyond. The right panel of *Figure 6* then displays the distributions of asset values conditional on age. The distributions tell a similar story, as assets typically increase until about age 65 and then decline. However, we also see that there is greater dispersion in assets as people age and experience different shocks or make different retirement timing decisions.

Figure 6: Saving Over the Life-Cycle

Average Assets by Age Group



Distributions of Assets by Age



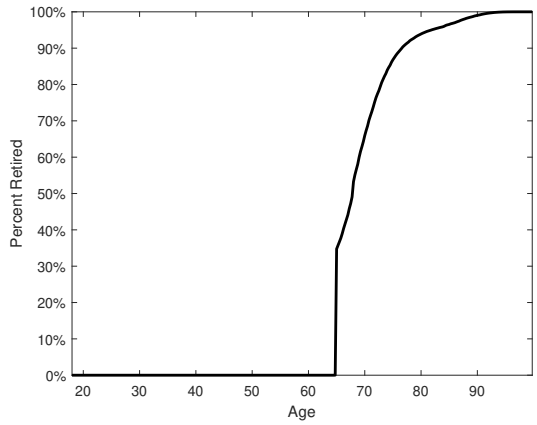
Next, the left panel of *Figure 7* displays the percentage of all agents who are retired at a given age. The figure shows that there is a spike in retirement at age 65, when agents are eligible to claim social security benefits. After age 65, the percent of agents who are retired quickly increases until the vast majority of individuals are retired by age 75 and effectively all are retired by age 90. When considering this and other figures that compare individuals of different ages in the model, it is important to remember that agents in the model die and exit the model with age-dependent probability $\nu(a)$. The left

[20]For this last moment we average the percentage change in median net worth between those 55-64 and 75+ using data only from the 1992 and 1995 waves of the Survey of Consumer Finances (SCF). This is because estimates obtained using later years vary significantly and in some cases are significantly positive. Data from the years 1992 and 1995 correspond to the start of our panel used in Section 3. SCF data was obtained from https://www.federalreserve.gov/econres/scfindex.htm.

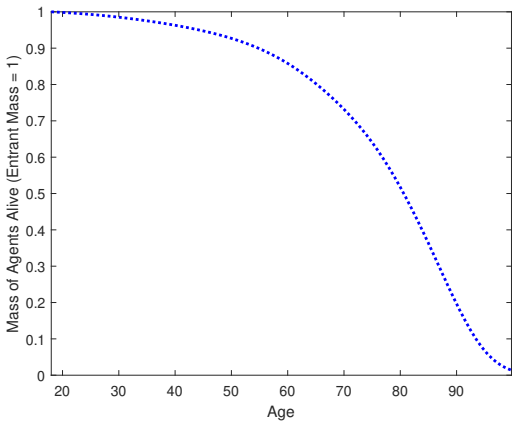
panel of the figure, and all other results comparing outcomes among different age groups, compute statistics using only the living population (e.g. the figure shows the percent of living agents who are retired). The right panel of *Figure 7* plots the share of individuals

Figure 7: Retirement and Death

Percent Retired by Age



Fraction Remaining Alive by Age



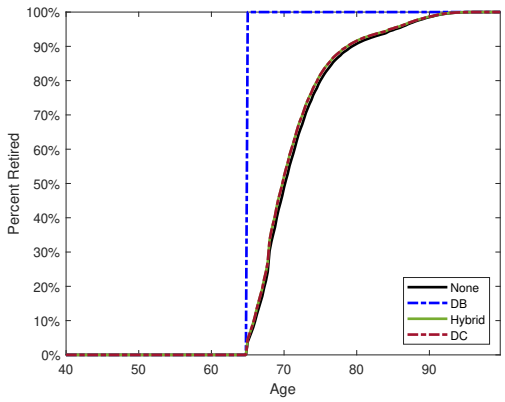
who have not yet died and exited the model at each age. Recall that a unit mass of agents enter the model at age 18 and then face death probabilities taken from the Social Security Administration's Actuarial Life Table. The probability of death is relatively low from age 18 to around age 50, after which it appears to increase exponentially.

While all individuals face the same death probabilities, the retirement plan they draw when entering the model has a significant impact on when they choose to retire. The left panel of *Figure 8* plots the percentage of individuals with each retirement plan who are retired by age. There is a clear jump into retirement at age 65 by all individuals enrolled in DB plans who become eligible to claim not only Social Security but also defined benefit pension income. While those not enrolled in DB plans also quickly begin to retire starting at age 65, their retirement decision is more dependent on the level of assets they have amassed, with wealthier individuals retiring earlier on average. Low-wealth individuals not enrolled in DB plans result in a small fraction of agents choosing to remain in the labor force into their 80s. The right panel of the figure compares the non-pension wealth (accumulated assets, b in the model) for those enrolled in DB vs. DC plans at different ages. The figure shows that those enrolled in DC plans endogenously accumulate significantly more wealth on average by the age of 65, relative to those in DB plans who are not as reliant on individually managed wealth to fund their retirement. However, while agents in DC plans accumulate more wealth on average than those in DB plans by age 65, individuals with DC plans consume a greater fraction of their assets after retirement. The figure shows that by age 90 those with DC plans have lower wealth on average, after eating through a larger portion of their savings in retirement.

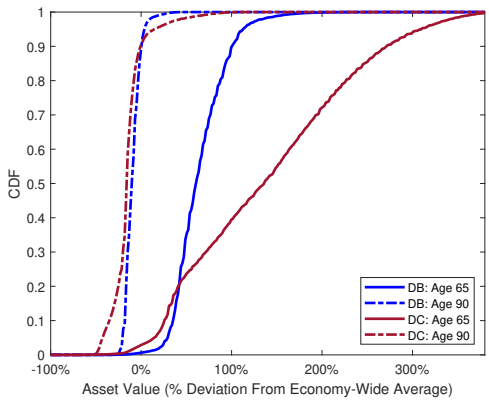
When comparing the accumulated wealth of individuals with different retirement plan

Figure 8: Savings and Retirement Timing Effects: DB vs. DC Plan

Percent Retired by Retirement Plan

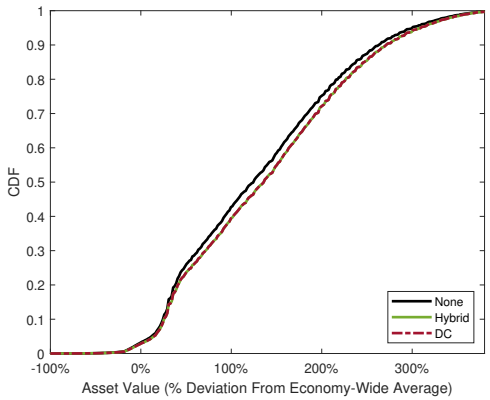


Asset Distributions by Retirement Plan



types, it is important to remember that those with DC and hybrid plans receive a contribution from their employer equal to 4.6% of their employment income into their pool of assets. This employer contribution does influence the distribution of assets available at given ages, but not as much as the incentives brought on by differences in how benefits are allocated after retirement. While *Figure 8* showed that the differences between DC and DB plans generate significantly different distributions of assets by age 65, *Figure 9* demonstrates that the distribution of assets for those in DC plans, who receive employer contributions, does not differ as dramatically when compared to the distribution among those with no retirement plan, who receive no employer contributions. Agents with no retirement plan do accumulate slightly fewer assets on average relative to those in DC plans, explaining why they also tend to retire slightly later compared to those in DC plans (*Figure 8*).

Figure 9: Assets by Age 65: DC vs. No Plan



5.3 Counterfactual: Movement from DB to DC Plans

Now, we use our model to evaluate the effects of the movement from DB to DC retirement plans shown in *Figure 1* from 1992 to 2020. The HRS data shows a decline in DB plans from including approximately 32% of respondents in 1992 to including just around 9% of respondents in 2020. While this movement away from DB plans occurred, the percent enrolled in a hybrid plan or no retirement plan remained relatively fixed. However, DC plan enrollment increased from approximately 20% of respondents to 43% of respondents over this same time-frame. The counterfactual that this subsection considers is a change in the probability of enrollment in DB and DC plans when agents enter the model. Specifically, we consider a decrease in the probability of DB plan enrollment from 0.32 to 0.09, and a corresponding increase in the probability of DC plan enrollment from 0.20 to 0.43. The probabilities of hybrid or no plan enrollment remain unchanged.

Table 6 displays the result of this movement out of DB and into DC plans. Unsurprisingly, the percentages of agents retired if age 65+, 70+, and 80+ are lower in the steady state of the economy with higher DC plan enrollment. The effect is greatest when looking at retirement among those 65+ because age 65 was when individuals with DB plans unanimously entered retirement while those in DC plans only began to retire passed on their accumulated wealth. Next, the table shows that average assets at age 65 and 85 are higher in the new steady state, as individuals must rely more on their own savings to fund retirement. However, average assets at age 90 are lower after the change because individuals with greater reliance on DC plans consume a larger portion of their savings if they reach later retirement. Finally, *Table 6* compares total utility in the steady states

Table 6: Steady State Comparison

	Movement from DB to DC
% Retired at Age 65+	-7.13 pp
% Retired at Age 70+	-3.56 pp
% Retired at Age 80+	-1.78 pp
Average Age 65 Assets	+8.14%
Average Age 85 Assets	+3.36%
Average Age 90 Assets	-1.42%
Total Utility (Including Value of Bequests)	-29.24%

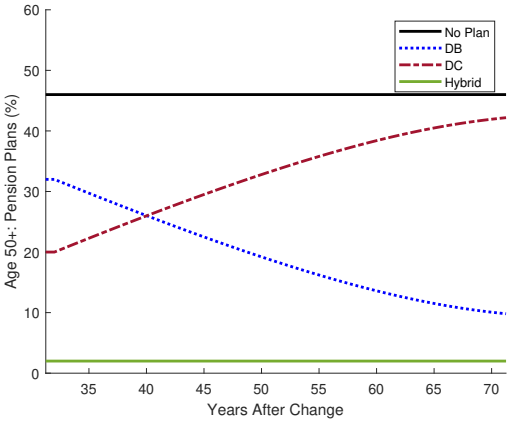
before and after the movement into DC plans. The table shows that the movement out of DB into DC plans decreases total utility (including the utility value of leaving bequests) in the economy by around 29%. Individuals not enrolled in DB plans face greater risk when planning for retirement, both due to the uncertain planning horizon and risk associated with uncertain rates of return. This result indicates that greater exposure to this risks can significantly reduce total utility.

While *Table 6* compare steady states before and after the transition away from DB

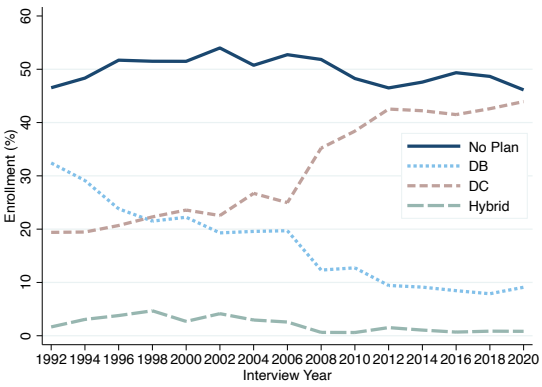
and towards DC plans, *Figure 10* considers the transition paths. The left panel of the figure displays the percent enrolled in each retirement/pension plan type among those age 50 and older (corresponding the HRS data, which included respondents age 50 and older) in the model. While we also considered more gradual shifts out of DB and into

Figure 10: Transition to Economy with Higher DC Plan Frequency

Model: Plan Type Among Age 50+



Data: Plan Type Among Age 50+



DC plans, we found that the shift that best reflected the movements in plan enrollment in the data was an immediate shift from a DB enrollment probability of 0.32 to 0.09 and from a DC enrollment probability of 0.20 to 0.43. Because *Figure 10* displays retirement plan type among those age 50+, there is a substantial lag of around 30 years between the change in new-agent enrollment rates and the observed change among individuals age 50+. It is worth pointing out that much of the climb in DC plan enrollment in the data occurs near 30 years after the Revenue Act of 1978 added section 401(k) to the Internal Revenue Code.

Figure 11 displays the transition paths of the percent retired among those 65+ in the economy after the shift from DB to DC plans the left panel of the figure shows that the decline in the share retired among those 65+ takes time to materialize, as age 18 entrants who are enrolled into DC plans at a higher frequency do not reach retirement age until more than 45 years later. However, after this first cohort enrolled with greater frequency into DC plans reaches age 65, we see a sharp drop in the percent retired. Notice that over the transition path, the percent age 65+ who are retired drops about 7.1 percentage points, corresponding with the roughly 7.8 percentage point drop in retirement this group in the data (*Figure 3*).

5.4 Counterfactual: Decomposing Effects of Uncertain Horizon and Uncertain Returns

To better understand how the shift from DB to DC plans results in a lower retirement rate among individuals age 65+, this subsection revisits the results previously displayed in

Figure 11: Results of Transition to Higher DC Plan Frequency

Difference in % Retired if Age 65+

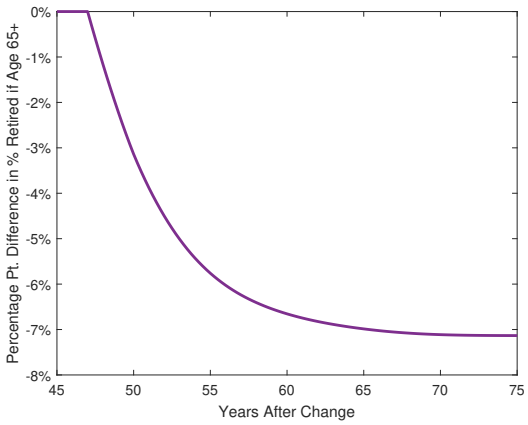


Table 6 after eliminating each of the two main sources of risk associated with planning for retirement in a DC rather than DB plan. Recall that there are two main uncertainties in the model related to retirement planning: uncertainty about one's lifespan and therefore planning horizon, and uncertain returns on private and DC plan investments. DB plans uniquely mitigate the first risk by providing fixed lifetime payments, while those without a DB plan must manage resources across an unpredictable lifespan. The second risk, related to investment returns, affects all individuals with private investments but is especially significant for those without a plan or relying on DC plans, as they depend more on potentially volatile investments for retirement funding.

To better assess how greater exposure to each of the two sources of risk associated with retirement planning contributes to our counterfactual results, we consider the same counterfactual after first removing uncertainty regarding the planning horizon and then removing uncertainty in the return on investments. *Table 7* displays the results of these counterfactuals in comparison to the full model with both sources of uncertainty present. The results in the first column of the table, labeled "Full Model" are those from our

Table 7: Steady State Comparisons: Excluding Sources of Risk

	Full Model	Certain Horizon	Certain Horizon & No Return Risk
% Retired at Age 65+	-7.13 pp	-2.71 pp	-0.15 pp
% Retired at Age 70+	-3.56 pp	-0.03 pp	0.00 pp
Average Age 65 Assets	+8.14%	+15.40%	+22.58%
Total Utility	-29.24%	-7.86%	-6.03%

original counterfactual exercise in *Table 6*. The next column, labeled "Certain Horizon" display the results of the same counterfactual shift from DB to DC plans with a model

where agents know they will die and exit the model at the age of 77.[21] Notice that after removing the uncertainty associated with an unknown planning horizon, the counterfactual drop in retirement is significantly lower, as is the drop in total utility. This result highlights the importance of retirement planning options that provide fixed payments for life.

Finally, the last column of *Table 7* shows the results of the shift from DB to DC plans when uncertainty regarding the rate of return is also eliminated. This is done by assuming that $\sigma_\epsilon = 0$, or equivalently that the risky rate of return r_r always equals the risk-free rate of return r_s. While the removal of uncertainty regarding returns further dampens the effect of the shift towards DC plans on retirement timing and total utility, the effect is not as large as the effect of removing uncertainty regarding the planning horizon. This result sheds light on the effectiveness of hybrid plans as potential substitutes for traditional DB plans. Hybrid plans remove uncertainty associated with uncertain returns to investments, but do not remove the uncertainty stemming from having to manage a pool of assets over an uncertain planning horizon. The counterfactual results generated by the model suggest that hybrid plans provide act more similarly to DC plans than DB plans.

6 Conclusion

The transition from defined benefit (DB) to defined contribution (DC) plans has significantly altered retirement planning in the United States. Our analysis highlights how this shift has increased individual control over retirement savings, while also raising exposure to risks associated with retirement planning, including uncertainties related to investment returns and the expected time spent in retirement. Using detailed panel data from the Health and Retirement Study (HRS) and a calibrated life-cycle model, we show that the rise of DC plans has significantly contributed to the observed decline in retirement rates among individuals aged 65 and older since the early 1990s.

DC plans incentivize higher private wealth accumulation prior to retirement relative to DB plans, reflecting individuals' need to self-insure against uncertain planning horizons and investment risks. However, those in DC plans exhibit more rapid wealth depletion in later years compared to DB participants, leading to lower average wealth among the oldest age groups. The model reveals that much of the increase in labor force participation among older individuals is driven by the heightened exposure to planning horizon/lifespan uncertainty under DC plans, underscoring the challenges associated with managing retirement under this framework. Overall, we show that the shift toward DC plans has notable implications for savings behavior, retirement timing, and welfare outcomes.

[21] This is the life-expectancy averaged over the life-expectancies for men and women in the Social Security Administration's Actuarial Life Table from which we retrieved the age-dependent death probabilities $\nu(a)$.

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A Data

A.1 Sample Selection

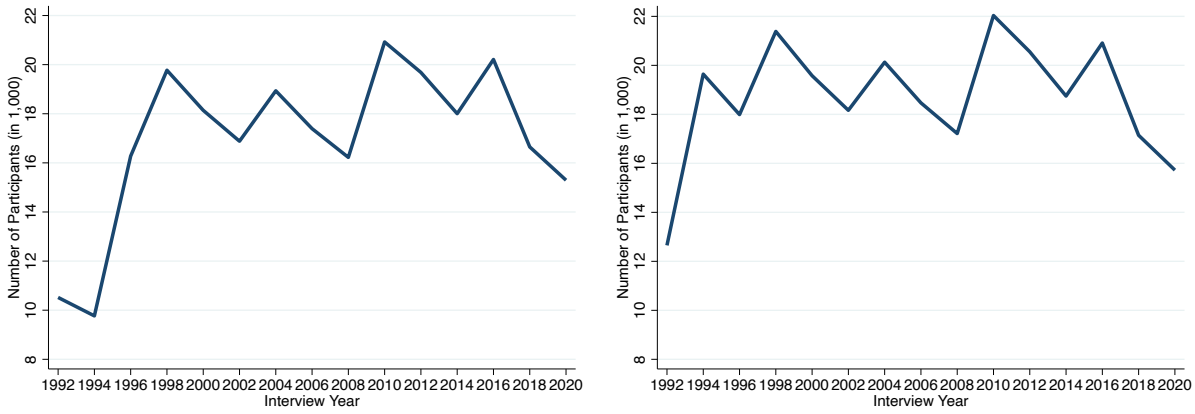
The original HRS dataset includes 280,343 unique individuals. We exclude participants missing key demographic information (age, race, or region), those already retired at their first interview, and those lacking valid data on labor force status, retirement plans, retirement status, health, or union coverage. Table 8 summarizes the sample size changes at each step.

Table 8: Sample Selection from HRS, 1992 to 2020

Sample Selection	**# of Obs.**	**# of Ind.**
Original panel	280343	42405
Drop participants without age info	280341	42404
Drop participants without race info	279908	42290
Drop participants without location info	279883	42281
Drop participants that completed retired since their first interview	237015	33271
Drop obs without labor force participation info	236358	33230
Drop obs if pension information is missing	235468	33173
Drop obs without retirement info	234801	33098
Drop obs without reported health info	234799	33096
Drop obs without union coverage info	233095	33036

Figure 12: Number of Participants in Each Interview Year

(a) Sample *(b) Original Panel*



We have 33,036 unique participants included in the sample, and the number of participants in each interview year is displayed in panel (a) of Figure 12. The number of participants in 1992 and 1994 is considerably lower than in other interview years. Comparing this to panel (b) of Figure 12, which shows the number of participants in the

original panel before cleaning, we find that the overall trend for participant numbers after 1996 in the sample is similar to that in the original panel. The lower participant count in 1992 in sample is primarily due to the smaller number of participants in the original panel, rather than the data cleaning process. The sharp decline in 1994 in the sample is because participants missing retirement plan records for their current jobs are excluded from the sample.

A.2 Additional Sample Descriptions

Table 9 summarizes the demographic composition of participants in the sample with individual weights adjustment. The sample contains almost equal proportions of female and male. The majority participants are White or Caucasian. Since the HRS survey primarily targets individuals over age 50 and their spouses, over half of the participants have a high school education or less, while around 23% have attended some college. Additionally, more than 92% of participants have been married at least once before exiting the study, indicating the importance of accounting for family or household effects when analyzing the impact of retirement plan choices on savings and retirement decisions.

Table 9: Compositions of Participants in Sample

Characteristics	Proportion
Gender	
Male	49.07%
Female	50.93%
Race & Ethnicity	
White/Caucasian	79.09%
Black/African American	11.73%
Other	9.18%
Highest Degree	
No Degree	16.64%
GED	4.58%
HS	26.89%
HS/GED	18.92%
AA	6.78%
BA	16.6%
MA/MBA	7.98%
Law/MD/PhD	1.59%
Marital History	
Ever Married	92.50%
Never Married	7.50%

Table 10: Distribution of Participants on Total Switches of Retirement Plans

Total Switch	Proportion of Participants
0	72%
1	15%
2	8%
3	3%
4	1%
More than 4	1%

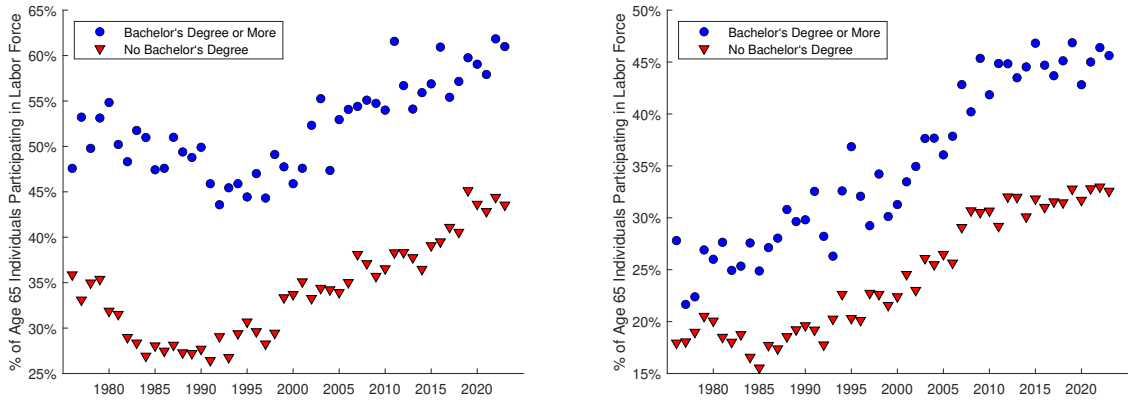
B Further Empirical Results

B.1 Decline in Retirement at Age 65

Figure 3 in the main text showed that the participation rate among age 65 individuals has been rising since the 1990s in the United States. Could some of this increase be due to difference in educational attainment during that time-frame, with more educated individuals tending to participate in the labor force later into the life-cycle? The following figure shows that the trend displayed in *Figure 3* is robust when separately looking at men and women with different levels of educational attainment.

Figure 13: Labor Force Participation at Age 65 by Education and Gender

Men *Women*



B.2 Empirical evidence related to Changes in Right-to-Work (RTW) Laws

This section applies a difference-in-differences approach to estimate the impact of the passage of the RTW laws, which is associated with a cut in union coverage (Fortin et al., 2023), on the coverage of DB plans. As mentioned in Section 3, this exercise provides additional evidence that union status is a strong instrument for the retirement plan type when estimating the Equation (1).

Table 11: Timetable for the passage of RTW laws in the U.S.

State	Year	State	Year
Alabama	1953	Nevada	1952
Arizona	1947	North Carolina	1947
Arkansas	1944	North Dakota	1948
Florida	1944	Oklahoma	2001
Georgia	1947	South Carolina	1954
Idaho	1985	South Dakota	1947
Indiana	2012	Tennessee	1947
Iowa	1947	Texas	1947
Kansas	1958	Utah	1955
Kentucky	2017	Virginia	1947
Louisiana	1976	Wisconsin	2015
Michigan	2012	West Virginia	2016
Mississippi	1954	Wyoming	1963
Nebraska	1946		

Data source: National Right to Work Committee website and state government websites.

The empirical strategy is shown in the Equation (11). $Y_{i,s,t}$ is the response variable to indicate DB plan inclusion. Table 11 summarizes the passage time of RTW laws in the U.S., which is used as the cutoff year to define the treatment group and control group. Since the passage of the RTW laws is more likely to affect the retirement plan for the new employees than the existing ones, we define the dummy variable, $postRTW$, as 1 if it is 30 years after the passage of the RTW laws.

$$Y_{i,s,t} = \beta postRTW_{s,t} + \boldsymbol{X_{i,s,t}} + \delta_t + \alpha_s + \epsilon_{i,s,t} \tag{11}$$

Table 12 demonstrates the difference-in-differences estimates of the impact of RTW laws on DB plan inclusion. Column (1) uses a stricter definition of DB plan inclusion than column (2). Nevertheless, the coefficients for the treatment in both columns show that fewer workers use DB plans as their first or second source of retirement income after the passage of RTW laws.

Table 12: Impact of RTW Laws on Inclusions of DB Plans

	(1)	(2)
	First source DB	First or second source DB
30 years after RTW	-0.0301***	-0.0299***
	(0.0058)	(0.0057)
Age	0.0011***	0.0011***
	(0.0001)	(0.0001)
Male	0.0345***	0.0345***
	(0.0018)	(0.0018)
Black	0.0355***	0.0354***
	(0.0032)	(0.0032)
Asian	-0.0250***	-0.0251***
	(0.0091)	(0.0091)
Other single race	-0.0114	-0.0118
	(0.0124)	(0.0123)
Two or more races	0.0026	0.0026
	(0.0112)	(0.0113)
Wages	-0.3728***	-0.3727***
	(0.0451)	(0.0449)
Constant	0.8299***	0.8299***
	(0.0080)	(0.0080)
Observations	184987	184987

Notes: Data is from the CPS Annual Social Economic Supplement. Standard errors are clustered at the state level. Stars denote statistical significance $^{*}p < 0.1$,$^{**}p < 0.05$, $^{***}p < 0.01$. Regressions include year fixed-effects and state fixed-effects. Estimations are adjusted by the ASEC weights. The sample age is from 18 to 75. The inclusion of DB plan is defined as 1 if the retirement income source is Company or Union pension, Federal Government retirement Pension, US Military retirement pension, State or local Gov't retirement pension, or US Railroad retirement pension.