Why Are Older Men Working More? The Role of Social Security

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Abstract

The labor supply of older men increased from the 1930s to the 1950s cohort. This paper explores the role of three Social Security changes in determining these differences: a delayed normal retirement age, increased delayed retirement credits, and a change in the earnings test that was eliminated beyond the retirement age, and evaluates the effects of several proposed reforms to the Social Security program on individuals' behaviors. I develop and estimate a rich dynamic life-cycle model of labor supply, savings, and Social Security application for healthy and unhealthy people using the Method of Simulated Moments for the 1930s birth cohort. The model captures the key structure of the Social Security retirement benefits, pension systems, and disability insurance, while taking into account uncertainties in health and disability, survival rates, wages, and medical expenditures. My model matches well the observed life-cycle profiles of employment, hours worked by workers, and savings for healthy and unhealthy people from the Panel Study of Income Dynamics data, and generates labor supply elasticities that rise with age and are smaller for healthy workers. It shows that the joint effects of the three changes in Social Security rules account for over 73% of the observed rises in labor force participation and hours per worker by the 1950s cohort. Of the three changed rules, the change in the earnings test contributes the most to the labor dynamics of older men. Additional policy experiments suggest that postponing the retirement age has little effect on older workers, while eliminating the earnings test and reducing retirement benefits by 23% would further increase older-age participation by 3.4 and 5.1 percent, respectively.

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1. Introduction

Over the past several decades, the labor supply of older men in the United States has been rising dramatically, along both extensive and intensive margins. For instance, data from the Current Population Survey (CPS) show that between 1995 and 2015, the labor force participation rates of men aged 65-69 increased by 10 percentage points: from 27% in 1995 to 37% in 2015.[1] Furthermore, annual hours worked by older workers increased by 15%, from 1,635 hours in 1995 to 1,878 hours in 2015.

This trend in older men's labor is particularly remarkable given that other age groups, such as younger men aged 21-55, exhibited a significant decline in work hours during the same period (Aguiar et al. (2018)).[2] During this time, Social Security rules in the United States had undergone significant changes, which might be major factors that led to the rise in the labor supply at older ages. For example, the normal retirement age (NRA) gradually increased from 65 to 67 for recent birth cohorts; delayed retirement credits (DRC) rose from 3% to 8% for new cohorts; and the retirement earnings test (RET) was removed beyond the NRA for those 65 and older beginning in 2000.[3]

To what extent do changes in the Social Security program rules account for the rise in the labor supply of older workers? Social Security is one of the most important social insurance programs for the elderly in the United States. It provides retired workers benefits that constitute the majority of their retirement income (Dushi et al. (2017)).[4] In 2019, the federal government spent about one-quarter of the annual federal budget on providing insurance benefits to 64 million Social Security beneficiaries, which accounted for 5% of the nation's gross domestic product (GDP).[5] However, as the U.S. population is aging rapidly, the fiscal solvency of public pension systems is under threat, and thus, changes to the scheduled benefits and policies for the Social Security program are needed.[6] Understanding the roles of existing Social Security program rules and their

[1] Author's calculations from the CPS. See Figure G.1 in Appendix G for more details. These rises in the employment of older men are also documented in, e.g., Blau and Goodstein (2010) and Rogerson and Wallenius (2021).

[2] Using data from the CPS, Aguiar et al. (2018) show that, from 2000 to 2015, the annual hours worked by men aged 21-30 decreased by 203 hours, about 11.8%, and those by men aged 31-55 decreased by 168 hours, about 8.2%.

[3] NRA: The age at which beneficiaries are entitled to full benefits without a reduction based on age. DRC: Retirement benefits are increased by a certain percentage (DRC) for each year if a worker delays application beyond the NRA. RET: The provision requiring the withholding of retirement benefits if beneficiaries under NRA have earnings above certain exempt amounts. It applied to beneficiaries below age 70 before 2000. See Section 3 for more information on Social Security rules.

[4] About 50% of Americans aged 65 or older live in households receiving over 50% of their family income from Social Security retirement benefits, and about 25% of them live in households receiving over 90% of their family income from retirement benefits. See more on Dushi et al. (2017).

[5] Source: `https://www.cbpp.org/research/federal-budget/where-do-our-federal-tax-dollars-go`.

[6] The Old-Age and Survivors Insurance Trust Fund is projected to be depleted around 2034 under currently scheduled benefits and financing. See Social Security Administration (2019) for more information on the projected financial status of Social Security programs.

changes on the recent labor supply trends of older workers is essential for policymakers' decisions on future Social Security policy reforms.

This research develops and estimates a structural model of labor supply, savings, and Social Security claims that incorporates social insurance programs to: 1) examine the extent to which three changes in the Social Security rules account for the rise in the labor supply of older men over time: an increased NRA, elimination of the RET beyond the NRA, and an increased DRC; and 2) evaluate the effects of several counterfactual Social Security policy reforms, such as postponing the retirement age, removing the earnings test, increasing payroll taxes, and reducing retirement benefits, on individual behaviors over the life cycle. To do so, I focus on two cohorts of American men: those born in the 1930s and 1950s, which correspond to men aged 60-69 in the mid-1990s and mid-2010s, respectively.[7] In addition, I disaggregate each cohort by health status because health has a sizable effect on labor supply behaviors over the life cycle, especially at older ages (e.g., French (2005)).

There are facts about these two cohorts that are important for analysis. Data from the Panel Study of Income Dynamics (PSID) show that the 1950s cohort, relative to the 1930s cohort, supplied more labor from age 60 to age 69, in terms of both labor participation rates and hours worked by workers. For instance, on average, participation rates at ages 60-69 for the 1950s cohort are 9.6 percentage points higher than those for the 1930s cohort, and hours worked by workers increased by 11.5% for the same age group between the two cohorts. Moreover, comparing labor supply behaviors by health status across cohorts over the life cycle, I find a new fact that these increases in participation rates and hours per worker across cohorts are mainly driven by people who were in good health.[8] In addition, compared to the older cohort, the younger cohort faced different Social Security rules: the NRA was postponed from age 65 to age 66; the RET was eliminated for individuals at the NRA or older; and the DRC was raised from around 4.5% to 8%.

To examine the role of changes in the Social Security rules on the increase in the labor supply of older men across cohorts, I first develop a dynamic life-cycle model for men born in the 1930s, which incorporates numerous details about social insurance programs, including Social Security retirement benefits and disability insurance. Individuals in my model choose how much they will work (including participation) and consume, and whether and when they will apply for Social Security benefits after reaching the early retirement age (ERA).[9] Individuals can receive

[7]The 1930s cohort refers to individuals born in the period 1920-1935 whereas the 1950s cohort refers to those born in the period 1945-1960.

[8]Health status is measured using the self-reported work limitation conditions from the PSID. Respondents reported having no limitations or having limitations. I define those who are healthy or in good health as anyone who reports no limitations and those who are unhealthy as anyone who reports limitations. Details are in Section 5.1.2. In addition, in Appendix B, I show that the changes in the participation and hours per worker across cohorts at older ages do not differ across other demographic groups, such as educational or occupational groups.

[9]ERA: the earliest age at which an individual can claim Social Security retirement benefits.

benefits at a higher level if they delay application. They can also work after receiving benefits, but will be subject to the earnings test.

My model framework builds on French (2005), a realistic life-cycle model of labor supply, Social Security application, and savings behaviors in which future health status, survival rates, and wages are uncertain. I further develop French's model by adding heterogeneity in health and incorporating the key features of disability insurance, health- and age-dependent medical expenditures, and a time-varying sequence of income taxes faced by a specific cohort. More specifically, my model incorporates the following main innovations.

First, I introduce a disabled state and explicitly model the disability insurance system. I include them for two purposes: 1) to distinguish between unhealthy individuals as either temporarily sick or disabled (e.g., Low and Pistaferri (2015)); and 2) to account for the fact that disabled and non-disabled people face different economic environments over their lifetime. For instance, the U.S. government provides disability benefits to people who are unable to work due to severe disabilities, and thus, those people can get the disability benefits and leave the labor market. Therefore, in some sense, Social Security rules are less important for them. By including the disabled state and the disability insurance system, my model matches the observed life-cycle profile of the labor force participation of unhealthy people (including both temporarily sick and disabled people) much more closely than a model that fails to account for disability and disability benefits.

Second, I add out-of-pocket medical expenditures, which depend on age and health status, to capture the fact that unhealthy individuals need to spend much more on medical services over their lifespan (e.g., De Nardi et al. (2018)). Incorporating the health gap in medical expenditures makes my model be able to match the observed differences in the savings profiles between healthy and unhealthy people over the life cycle.

Third, instead of using tax structures in one particular year to calibrate the tax parameters of the structural model, e.g., French (2005) and Bairoliya (2019), I adapt a time-varying sequence of income tax rates faced by a specific cohort at each age during their lifetime, which is a function of annual earnings. It is intended to capture the progressive income taxes that change every year for a specific cohort (e.g., Borella et al. (2019a)). Hence, not only is my model richer, but it can also match more important life-cycle outcomes.

Next, I estimate my dynamic structural model for the 1930s cohort using the Method of Simulated Moments (MSM) and data from the Panel Study of Income Dynamics (PSID) and the Medical Expenditure Panel Survey (MEPS).

My estimated model matches the observed life-cycle profiles of labor force participation, hours worked by workers, and assets for healthy and unhealthy individuals for the 1930s cohort very well, and it generates the labor supply elasticities by age and health. My model generates that elasticity rises with age, and unhealthy people have higher values of elasticities over ages, which, to the best of my knowledge, has not been documented by previous literature.

I then use my estimated model to examine the role of Social Security policy changes on the increase in the labor supply of older men between the 1930s and 1950s cohorts. Taking the estimated preference parameters from the 1930s cohort as given, I apply the changed Social Security rules – normal retirement age, the earnings test, and delayed retirement credits – faced by the 1950s cohort to the estimated model of the 1930s cohort, and I simulate how the older cohort would behave if they had the same values for those policies as the younger cohort. My model shows that the joint effects of these three changed rules explain 73.4% and 88.7% of the observed rises in the labor force participation and annual hours worked per worker at ages 60-69, respectively, across cohorts. Of the three changed rules, eliminating the RET beyond the NRA contributes the most to these increases – it accounts for 71.1% of the rise in participation and 86.8% of the rise in working hours per worker at older ages.

Given the success of my estimated model in explaining labor supply behaviors between the two cohorts, I then use my model to evaluate the impacts of several Social Security reform proposals. I conduct three sets of counterfactual experiments. The first set of experiments delays the ERA by two years, from age 62 to 64, or postpones the NRA by two years, from age 66 to 68. The second set of experiments eliminates the RET for all beneficiaries under the NRA. In the third set of experiments, I raise payroll tax rates by 1.57 percentage points or cut retirement benefits by 23%, which were proposed by the Social Security Administration (2020).[10]

More specifically, I use my estimated model to evaluate these policy reforms' effects on individual behaviors, such as labor supply, savings, consumption, and Social Security application. Also, to isolate the impact of these alternative reforms, I keep other Social Security rules and model parameters unchanged when conducting each policy experiment.

My model's predictions suggest that shifting the ERA has almost no effect on individual behaviors. In addition, as postponing the NRA increases the reduction factor of retirement benefits in the early 60s, individuals will delay Social Security application, and save and work more to finance the delay. The average assets at the ERA will increase by 2.2%, and the older-age participation will increase by 0.9 percentage points. In the second experiment, removing earnings test for all beneficiaries will induce a 28-percentage-point increase in the fraction of benefits application at the ERA. The average consumption and older-age participation will increase by 0.7% and 3.4%, respectively, especially for unhealthy people, whose participation at 60-69 will increase by 8.2%. In the third set of experiments, reducing benefits and raising payroll taxes both induce an increase in the hours per worker at younger ages, 30-59, and a sizable decline in the fraction of early benefit applicants. However, raising the payroll tax will discourage labor force participation over the life

[10] For more proposals and options to address the solvency problem of Social Security programs, see `https://www.ssa.gov/oact/solvency/index.html`.

cycle and decrease both consumption and savings, whereas cutting benefits will increase savings and labor supply over the life cycle. Specifically, participation at older ages will increase by 5.1%, and average assets at the ERA will increase by 3.2%. In the latter case, to avoid additional reductions due to early application, many will delay the benefits claiming, and they will save more and work more at older ages to finance retirement due to delayed application and fewer lifetime retirement benefits.

This paper contributes to the literature on trends in older male workers' labor supply and retirement in three major ways: 1) it explores the increase in the labor supply of older workers; 2) it uses a structural model to explain those changes; and 3) it complements broader research on Social Security in the United States and globally.

More specifically, first, this study contributes to a large body of literature in documenting and explaining the increase in the labor supply of older men in the United States. For instance, Schirle (2008) documents that the rise in the employment of older men has primarily been driven by married men and examines the shared leisure effects of increased wives' participation, and Maestas and Zissimopoulos (2010) study the effects of shifts in the workforce skill composition on the rise in older men's participation. More recently, Rogerson and Wallenius (2021) have presented narratives stressing older female employment and institutional changes as the driving forces behind the rise in the employment of older males; while Cajner et al. (2021) find that the compositional changes in occupation, education, health, and the spousal employment status play no statistically significant role in explaining the participation increase for older men between the 1934 and 1953 cohorts. My paper contributes to this string of literature by 1) documenting a new fact that the increases in the labor supply of older workers are mainly driven by people who were in good health, in terms of both extensive and intensive margins; 2) estimating the contribution of the Social Security policy changes using a structural model; and 3) showing that the Social Security change in the earning test explains over 70% of the labor dynamics at older ages. Compared to the reduced-form approach (e.g., Friedberg (2000), Engelhardt and Kumar (2014), and Gelber et al. (2018)), a structural framework allows individuals to optimally choose and adjust their decisions when facing uncertainties (such as shocks to health status and medical expenditure) and different financial incentives for retirement (such as public pension and health insurance programs) over their life cycle, e.g., Rust and Phelan (1997), Casanova (2010) and Braun et al. (2017). It is difficult to disentangle those competing incentives when they are not modeling explicitly in non-structural analyses. A structural framework allows us to investigate individuals' behavioral responses to policy changes using estimated parameters (e.g., Haan and Prowse (2014)).[11]

[11]Many papers have studied the effects of public pensions in a general equilibrium life-cycle framework, e.g., Imrohoroğlu and Kitao (2012) and Fuster et al. (2007), which account for general equilibrium effects such as price changes. However, as French and Jones (2012) discuss, the predicted values of those studies largely depend on the calibrated model parameters, which lack sufficient empirical justification, and most of them ignore the age-varying

Second, this paper is the first to analyze the contribution of Social Security changes across different cohorts on observed changes in term of the labor supply of older workers along both margins in a structural framework. Most existing studies examine a specific or representative cohort for the entire population to study the labor supply and retirement behavior as a response to changes in the economic environment using structural models, e.g., Groneck and Wallenius (2017) and Fan et al. (2019). The former studies the impact of Social Security auxiliary benefits on married women's employment, whereas the latter paper highlights the importance of human capital investment in understanding the life-cycle labor supply. My research contributes to the literature by filling this gap. Even though the labor supply across cohorts has been studied in, e.g., Attanasio et al. (2008) and Park (2018), the population of interest is different. They investigate the between-cohort changes of women's behaviors; while my paper focuses on the rise in older men's labor supply across cohorts, which few scholars have explored. Specifically, Bairoliya (2019) evaluates the impact of pension composition changes on the rise in the labor supply of the elderly using a structural model over older ages. In my paper, I evaluate the labor supply effects of Social Security rules using a whole life-cycle model that incorporates a disabled state and disability insurance. Those help explain the labor behaviors of unhealthy people and capture the dynamic effects at the earlier stage for policy counterfactuals. Further, instead of explaining between-cohort labor behaviors, Borella et al. (2019b) document the between-cohort changes in life expectancies, medical expenses, and wages and uncover their effects on the labor market outcomes over the life cycle. My approach, by contrast, documents changes in the labor supply across cohorts and explains these changes using the changing economic environment.

Finally, my paper complements the extensive literature on analyzing the effects of Social Security or public pension reforms. For instance, French and Jones (2011) predict that increasing the eligibility age for Social Security has a larger impact on older male workers than that for Medicare; French (2005) highlights the work disincentives of the retirement earnings test; and Jones and Li (2018) suggest that reforms to the benefits tax deserve serious consideration.[12] My work complements those previous studies by comparing two cohorts over time and with a richer model that includes heterogeneity in health and the main features of disability insurance. These elements are helpful to match individual behaviors by health and analyze the effect of retirement policy reforms. Further, in addition to generating labor supply elasticities rising with age, which is consistent with previous studies, my model also generates different elasticities by health with age, which previous literature missed. As my model fits well the 1930s cohort's behaviors by the construction and explains well the behaviors of the 1950s cohort after changing the Social Security

labor supply elasticities over the life cycle.

[12] Instead of focusing on the U.S. social insurance programs, papers including Erosa et al. (2012) and Laun and Wallenius (2016) document cross-country differences in the labor supply of the elderly and study the role of social insurance programs in these cross-country differences.

policies that I do not match by construction, it provides a valid benchmark to evaluate proposed Social Security policy reforms.

The rest of the paper is organized as follows. Section 2 documents empirical facts about the recent trends in the labor supply for the 1930s and 1950s cohorts. Section 3 describes the changed Social Security rules faced by the 1950s cohort, relative to the 1930s one. Section 4 describes my structural model. Section 5 discusses the estimation procedure. Section 6 presents the estimation results of my model. Section 7 investigates how those changes in the Social Security rules explain between-cohort changes in the labor supply using the estimated model. Section 8 evaluates the effects of several reforms to the Social Security rules on individual behaviors. Section 9 concludes.

2. Labor Market Outcomes Across Cohorts

In this section, I document the changes that occurred between the 1930s and 1950s cohorts in the labor supply over the life cycle, as well as the changes by health status across cohorts.[13]

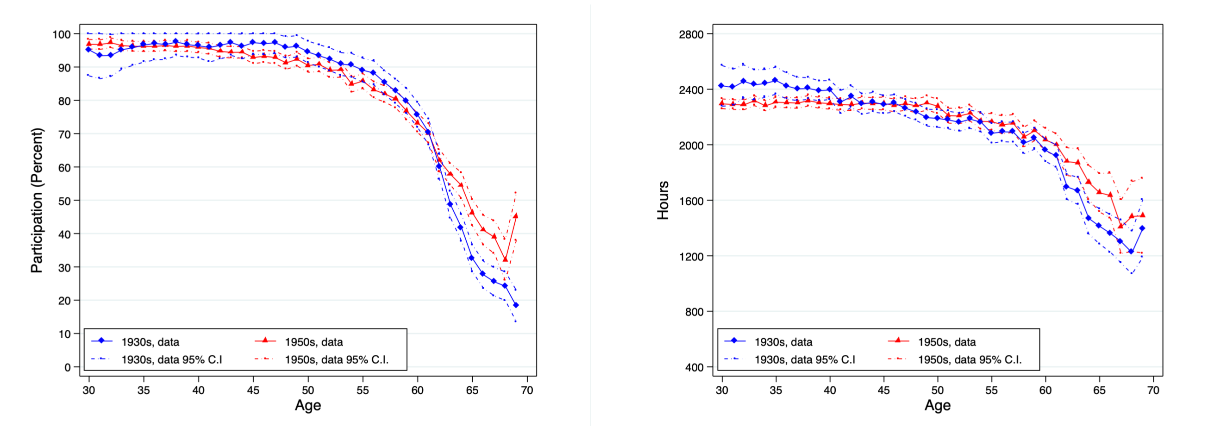
2.1. Data

I use the 1968-2015 waves of the PSID and pick the cohort born in the 1930s (comprising the 1920-1935 birth cohorts) and the 1950s one (comprising the 1945-1960 birth cohorts). I use the labor supply, income, and health variables for the male household head from the PSID to construct the profiles of labor force participation and hours worked by workers over the life cycle. Appendix A reports more information about the data.

I start with 76,880 individuals and 3,075,200 observations. Following French (2005) and Borella et al. (2019b), I drop the Survey of Economic Opportunity (SEO) sample to make the data more representative of the U.S. population, keep male household heads and their spouses, if present, and restrict the sample to ages 20-90. My resulting sample comprises 984 individuals and 20,091 observations for the 1930s cohort, and 2,844 individuals and 45,945 observations for the 1950s cohort. Table A.1 in Appendix A displays the sample sizes before and after applying my selection criteria.

[13]In Appendix B, I also look at the changes in the labor supply between the two cohorts across other demographic groups, such as educational attainment and the employment sector, using data from the PSID. I show that both data profiles of participation and hours per worker between the two cohorts are not significantly different by educational and occupational groups.

2.2. Life-Cycle Patterns: American men



(a) Labor Force Participation (b) Hours Worked by Workers

Fig. 1. Labor Supply Across Cohorts

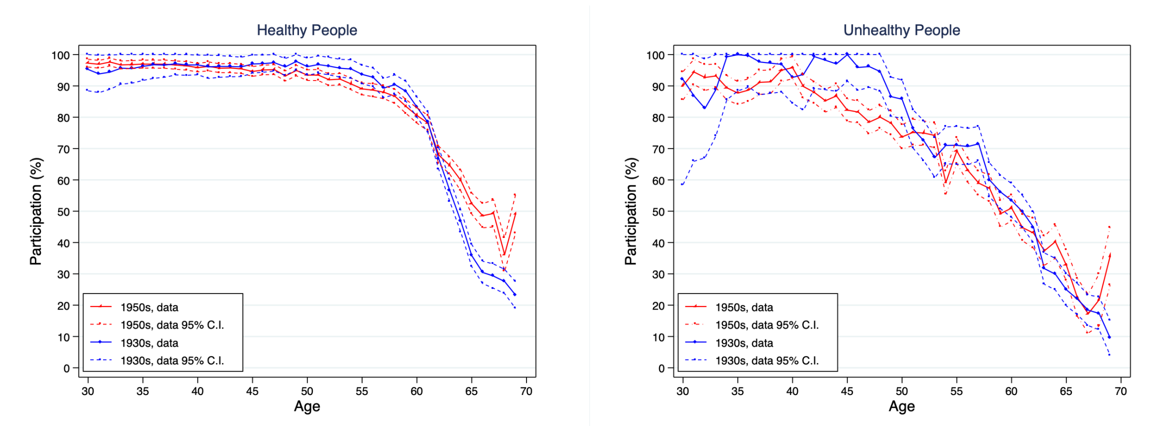
Notes: Data profiles of life-cycle labor participation (panel a) and hours worked by workers (panel b), comparing the 1930s (blue) and the 1950s (red) cohorts for American men. The 95% confidence intervals are represented by dotted lines.
Data Source: Panel Study of Income Dynamics, author's calculations.

Figure 1 displays the resulting data profiles of labor force participation and hours worked by workers (left and right panels, respectively) over ages 30-70 for both cohorts.[14] It shows that the participation and hours per worker decline steeply after age 60 for both cohorts, but that the 1950s cohort has higher participation rates and hours worked at older ages. For instance, on average, participation rates at ages 60-69 for the 1950s cohort are 9.6 percentage points higher than those for the 1930s cohort, and 15 percentage points higher for the age group 65-69. Moreover, between the two cohorts, hours per worker increased by 10.2% and 25.7% for the age groups 60-69 and 65-69, respectively.

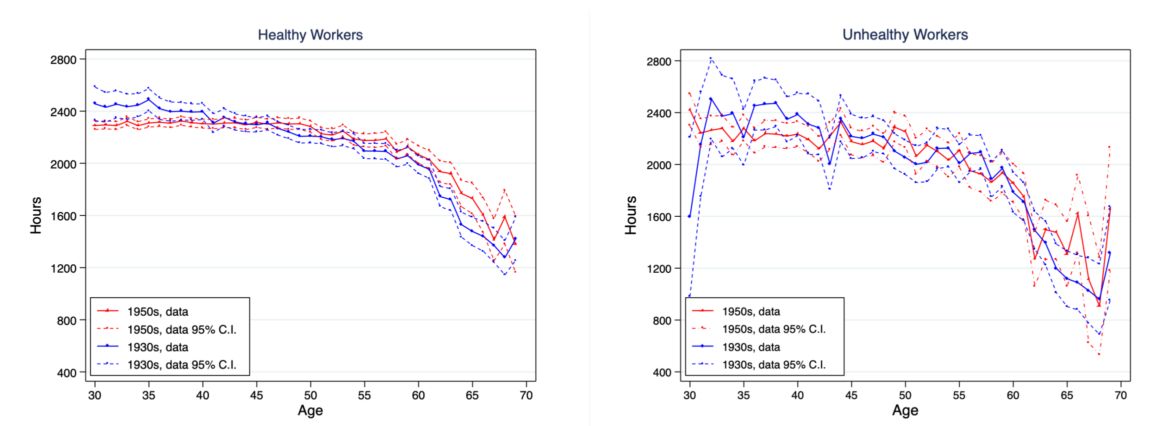
2.3. Life-Cycle Patterns: By Health

Figure 2 shows the life-cycle profiles of labor force participation and hours worked conditional on participation by health status (left panels: healthy; right panels: unhealthy). There are

[14]Labor force participation is defined as the fraction of individuals whose annual hours worked were more than 300. Hours worked is measured as of the survey. The profiles of participation and hours worked by workers are estimated by running a fixed-effect regression for each variable on a set of variables. I control for the birth-year effect, family effect, year effect, and individual effect to obtain the average profile in levels. Details are in Section 5.3.



(a) Labor Force Participation by Health Status



(b) Hours Worked by Health Status

Fig. 2. Labor Supply Across Cohorts By Health Status

Notes: Data profiles of life-cycle labor participation (panel a) and hours worked by workers (panel b), comparing the 1930s (blue) and the 1950s (red) cohorts for healthy people (left panels) and unhealthy people (right panels). The 95% confidence intervals are represented by dotted lines.

Data Source: Panel Study of Income Dynamics, author's calculations.

several patterns worth noticing. First, the effects of health on the labor supply are sizable over the life cycle. Specifically, participation rates of healthy people begin to decline around age 60 and decline sharply in the 60s. In contrast, the participation rates of unhealthy people start declining from age 40 and do so more slowly. At age 55, for example, the participation rate of unhealthy people is 23 percentage points lower than that of healthy people of the 1930s cohort. Second, the increases in the participation rates and hours worked by older workers occurring between the 1930s and 1950s cohorts mainly come from people in good health. The behavior of unhealthy people did not significantly change across cohorts.

These observed changes in the labor force participation and hours worked profiles both motivate my research and are the target moments for my structural estimation. In the next section, I discuss the changes in the Social Security rules faced by these two cohorts that are likely to be important determinants of the labor supply and retirement choices.

3. Background: Changes in Social Security Rules

Social Security is the largest income-maintenance program in the United States. The Social Security trust funds are financed by payroll taxes on workers and provide insurance benefits to eligible workers and their families to replace, in part, the loss of income due to retirement, disability, or death. The trust funds consist of two parts. Retired workers, their families, and survivors of deceased workers receive retirement benefits under the Old-Age and Survivors Insurance (OASI) program. Disabled workers and their families receive disability benefits under the Disability Insurance (DI) program. As of 2020, about 180 million people worked and paid taxes and about 65 million people received Social Security benefits. Most of the beneficiaries are retirees and their families — about 49 million people.[15]

For American men aged 65 or older, Social Security is an essential source of retirement income. As reported in Social Security Administration (2021), retirement benefits replace about 78%, 42%, and 28% of pre-retirement income for very low earners, medium earners, and high earners, respectively, if they claim benefits at their NRA.

Workers are eligible to receive Social Security retirement benefits by paying payroll taxes on their wages during their working years. The amount of retirement benefits that a worker can receive depends on his Average Indexed Monthly Earnings (AIME), which is roughly a worker's average income based on his highest 35 years of earnings.[16] A formula is then applied to the AIME

[15] Source: Social Security Fact Sheet, Social Security Administration.

[16] An individual's earnings up to two years before eligibility (currently age 60) are indexed to average wage growth to ensure that a worker's future benefits reflect the general rise in the standard of living that occurred during his working lifetime. Years with no earnings are entered into the average as 0s. After age 60, nominal earnings are used in the

to calculate a worker's basic benefit, or Primary Insurance Amount (PIA), which is the amount to be received at the NRA. Workers can begin receiving retirement benefits after reaching the ERA of 62, but these benefits will be lower if workers claim them before the NRA. In contrast, benefits will be higher (by a certain percentage – DRC) if workers delay the application beyond the NRA and up until age 70. Both NRA and DRC vary by year of birth, whereas the ERA is the same for everyone. In addition, workers are allowed to work for pay while receiving retirement benefits, but they are subject to an earnings test, which causes a reduction of the benefits level in that period. Thus, the NRA, DRC, and the age at which the earnings test applies are essential factors affecting workers' labor supply and retirement decisions at older ages. In what follows, I describe the observed changes in the Social Security rules faced by American men born in the 1950s compared with those born in the 1930s.

Table 1: Social Security Rules for People Born in 1920-1960

Year of Birth	NRA (1)	DRC (%) (2)	RET (3)
1920 - 1924	65	3	70
1925 - 1926	65	3.5	70
1927 - 1928	65	4	70
1929 - 1930	65	4.5	70
1931 - 1932	65	5	70
1933 - 1934	65	5.5	70
1935 - 1936	65	6	NRA
1937	65	6.5	NRA
1938	65 and 2 months	6.5	NRA
1939	65 and 4 months	7	NRA
1940	65 and 6 months	7	NRA
1941	65 and 8 months	7.5	NRA
1942	65 and 10 months	7.5	NRA
1943 - 1954	66	8	NRA
1955	66 and 2 months	8	NRA
1956	66 and 4 months	8	NRA
1957	66 and 6 months	8	NRA
1958	66 and 8 months	8	NRA
1959	66 and 10 months	8	NRA
1960 or Later	67	8	NRA

[1] Abbreviation: NRA = Normal Retirement Age; DRC = Delay Retirement Credit (%); RET = Retirement Earnings Test.
[2] Notes: Columns 1 and 2 report the normal retirement age and delayed retirement credits faced by individuals in each birth cohort. Column 3 reports the age that the retirement earnings test is removed.
[3] Source: Social Security Administration.

benefit formula without any indexation. See Social Security Advisory Board, December 2010 for more information.

Using data from the Social Security Administration (SSA), I summarize NRA and DRC for people born between 1920 and 1960 in columns (1) and (2) of Table 1.[17] Compared to the 1930s cohort with NRA of 65 and DRC of 4.5% on average, the younger cohort has NRA at age 66 and DRC of 8% on average. For instance, if a person in the younger cohort retires one year after the NRA, his retirement benefits will increase by 8% permanently. In contrast, if a person in the older cohort retires one year after the NRA, his retirement benefits only increase by 4.5%, on average. Table 2 summarizes the effects of applying for retirement benefits at ages 62-70, which are expressed as the percentage of unreduced benefits at the NRA, under different rules of NRA and DRC faced by the two cohorts.

Table 2: Effects of Early or Delayed Social Security Claiming

			Benefit, as a percentage of PIA, payable at age								
Cohort	NRA	DRC(%)	62	63	64	65	66	67	68	69	70
1930s	65	4.5	80	86.67	93.33	100	104.5	109	113.5	118	122.5
1950s	66	8	75	80	86.67	93.33	100	108	116	124	132

[1] Abbreviation: NRA = Normal Retirement Age; DRC = Delay Retirement Credit (%); PIA = Primary Insurance Amount.
[2] Notes: Table shows the Social Security retirement benefits, expressed as the percentage of Primary Insurance Amount, that an individual can receive if he claims at ages 62-70.
[3] Source: Social Security Administration, author's calculations.

Workers from the 1930s cohort can get 80% of their full retirement benefits at 62 and 122.5% of benefits at 70, whereas workers from the 1950s cohort can only receive 75% of their full retirement benefits at 62, which is 5 percentage points lower than the older cohort, but 132% of benefits at 70, which is 9.5 percentage points higher than 1930s cohort. Therefore, both changes in the NRA and DRC encourage the younger cohort to work more at older ages and delay retirement.

Moreover, from the year 2000, there has been a change in the retirement earnings test, which prevented workers from collecting their retirement benefits while simultaneously earning money from working. Before 2000, workers who had reached age 62 but had not yet reached 70 were subject to the RET. More specifically, retired workers from the 1930s cohort who already collected their retirement benefits faced a 50% tax rate on their labor income between age 62 and the NRA and a 33% tax rate between the NRA and age 70, until all their retirement benefits were taxed out. Although the benefits lost due to the earnings test could be recouped in the future, these high income

[17] SSA links for NRA and DRC: `https://www.ssa.gov/oact/progdata/nra.html`; `https://www.ssa.gov/benefits/retirement/planner/delayret.html`.

rates discouraged workers' labor supply.[18] After 2000, however, this earnings test was removed for individuals beyond the NRA. Only workers under the NRA are subject to the earnings test at a 50% tax rate. The ages at which the RET is removed for people born between 1920 and 1960 are summarized in column (3) of Table 1. Hence, workers in the younger cohort who reached the NRA can keep both their retirement benefits and labor income without reduction, as long as their income is below a certain threshold. Therefore, eliminating the RET beyond the NRA encourages workers to work more at older ages.

4. The Model

This section describes a dynamic life-cycle model of consumption, labor supply, and Social Security claiming which incorporates the key aspects of social insurance programs, such as Social Security retirement benefits, disability insurance, and pension plans.

Time is discrete and indexed by t. A model period is one year long. Consider a male household head seeking to maximize his expected lifetime utility at age $t, t = t_0, t_1, t_2 \ldots, T$. People enter the model at age 25 and they live up to a maximum age of 95. In each time period (or age) t, a male household head faces uncertainty in health and disability status, mortality risk, wages, and medical expenditure. Individuals make decisions on how much to consume, how much to work (including both labor force participation and hours worked decisions), and whether to apply for Social Security retirement benefits (if eligible).[19]

4.1. ***Preferences***

Each individual in period t derives utility from consumption, c_t and leisure, l_t. The within-period utility function from consumption and leisure is given by:

$$u(c_t, l_t) = \frac{1}{1-\nu}\left(c_t^{\gamma}\, l_t^{1-\gamma} \right)^{1-\nu} \tag{1}$$

[18]Beneficiaries can recoup the benefits lost due to the earnings test in the future. For example, benefits are recalculated at the NRA to account for periods in which earnings tests were applied. This benefit re-computation adjusts the actuarial reduction for early application and results in a permanently higher benefit for retired workers.

[19]The model framework follows French (2005) and French and Jones (2011). My model does not explicitly include the heterogeneity in education, marital status, and occupation. As shown in Appendix B, data profiles of participation and hours per worker between the two cohorts are not significantly different by educational and occupational groups. Also, Cajner et al. (2021) show that changes in occupation, education, and spousal employment status play no statistically significant role in explaining the increase in participation of older men across cohorts.

where γ is between 0 and 1 and ν is positive. The parameter γ is the weight on consumption. Individuals with a higher value of γ have stronger preferences for work. The parameter ν is the coefficient of relative risk aversion (CRRA) and controls the intertemporal substitutability of consumption and leisure. Individuals with a higher value of ν become less willing to intertemporally substitute. The parameter ν also measures the non-separability between consumption and leisure. Under perfect foresight and positive consumption and working hours, $\nu > 1$ implies that consumption and leisure are Frisch substitutes (see Low (2005) and French and Jones (2011)).

Leisure in period t is given by:

$$l_t = L_t - n_t - \theta_p^{h_t} p_t - \phi \mathbb{1}_{\{h_t \neq 0\}} \tag{2}$$

where L_t is an individual's total annual time endowment; n_t is hours worked; p_t is a 0-1 indicator of participation in the labor market that is equal to 1 when n_t is positive and zero otherwise; θ_p is the fixed cost of working (measured in hours per year). It includes time spent getting ready for work, including commuting time. I allow the fixed cost to depend on health and disability status, $h_t \in \{0, 1, 2\}$, which takes three values and can be good health (healthy) $(h_t = 0)$, bad health (unhealthy) $(h_t = 1)$, or disability (unhealthy) $(h_t = 2)$. In this model, retirement arises endogenously as part of the labor participation decision, and individuals can reenter the labor market. Moreover, there will be an amount of leisure loss due to unhealthy status, ϕ, which is measured in hours per year. It captures the time spent in physical therapy, doctor visiting, etc. Therefore, compared to healthy individuals, people who are unhealthy face different fixed costs of working and annual available time even if they do not work.[20]

4.2. Health, Disability, Mortality, and Medical Spending

In each time period, individuals face uncertainty in health, $h_t \in \{0, 1, 2\}$, with 0 being in good health, 1 being in bad health, and 2 being in a disabled state. Health in the next period, $h_{t+1} \in \{0, 1, 2\}$, depends on the individual's current health and age, and evolves according to the Markov chain between three states, with an age-dependent Markov transition matrix. A typical element of the health transition matrix at age t is given by:

$$\pi_{j,i,t+1} = Pr(h_{t+1} = j | h_t = i, t+1), \qquad i, j \in \{0, 1, 2\} \tag{3}$$

The lifespan is uncertain. The parameter s_{t+1} denotes the probability that an individual is alive at age $t+1$ conditional on being alive at age t. The survival probability depends on age and previous health status, as: $s_{t+1} = S(h_t, t+1)$. Because individuals live up to a maximum age T,

[20] I assume that unhealthy individuals ($h_t = 1, 2$) share the same fixed cost of working $\theta_p^{h_t}$ and leisure loss ϕ.

$s_{T+1} = 0$ for any h.

Let m_t denote the out-of-pocket medical expenditure at age t, which depends on age and health status, i.e., $m_t = M(h_t, t)$. The m_t is defined as the individual's total medical expenditure net of medical coverage provided by insurance, such as Medicaid, Medicare, etc.[21] Age- and health-dependent medical expenditure are intended to capture the fact that people spend more on out-of-pocket medical services as they age or health status gets worse (e.g., De Nardi et al. (2018)).

4.3. ***Wages and Spousal Earnings***

The logarithm of hourly wages at age t, $\ln w_t$, is a function of health status and age, $W(h_t, t)$, and an autoregressive component of wages, ω_t, as follows:

$$\ln w_t = W(h_t, t) + \omega_t \tag{4}$$

$$\omega_t = \rho \omega_{t-1} + \eta_t, \quad \eta_t \sim N(0, \sigma_\rho^2) \tag{5}$$

The autoregressive component ω_t has the correlation coefficient, ρ, and a normally distributed innovation, η. For more details about the function $W(h_t, t)$ and stochastic components (ρ, σ_ρ^2), see Section 5.1.5.

Spousal earnings are modeled as a function of a male household head's wages, age, and health status:

$$ys_t = ys(w_t, h_t, t) \tag{6}$$

which can serve as insurance against uncertainties over the life cycle. The details of the function $ys(\cdot)$ are in Section 5.1.6.

4.4. ***Social Security, Disability Benefits, and Pension***

Social Security benefits are modeled in great detail to match the current U.S. system. Once an individual reaches the ERA, he becomes eligible to claim Social Security retirement benefits. Social Security application decision is a one-time decision and irreversible. Individuals receive no retirement benefits before claiming. Upon applying, individuals collect the benefits (subject to the earnings test), ss_t, until their death. As discussed earlier in Section 3, the lifetime career earnings ($AIME_t$), claiming age, and labor income after collecting benefits (through the earnings test) are the three main factors affecting an individual's retirement benefits.

[21] The model abstracts from heterogeneity in insurance. Health insurance status and types are explicitly modeled in, e.g., Imrohoroğlu and Kitao (2012) and Blau and Gilleskie (2008).

First, the level of retirement benefits depends on an individual's $AIME$, which are calculated using the average of his highest 35 years of earnings. This causes work incentives to drop after 35 years in the labor market, since for the workers who have been working more than 35 years, working an additional year will increase their $AIME$ only if their labor income exceeds the lowest earnings in some previous years. Let $aime_t$ denote the annualized measure of $AIME$. Since individuals are assumed to enter the model at age 25, $aime_t$ evolves according to

$$aime_{t+1} = \begin{cases} \max\{aime_t + \frac{w_t n_t}{35}, aime_{max}\} & \text{if age} < 60 \\ \max\{aime_t + \max\{0, \frac{w_t n_t - aime_t}{35}\}, aime_{max}\} & \text{if age} \geq 60 \end{cases} \tag{7}$$

where $aime_{max}$ denotes the threshold in which $aime_t$ is capped. Then PIA_t is computed using a piecewise linear function of $aime_t$ given as follows.

$$\begin{aligned} PIA_t = & \ 0.9 * \min\{aime_t, aime_0\} \\ & + 0.32 * \min\{\max\{aime_t - aime_0, 0\}, aime_1 - aime_0\} \\ & + 0.15 * \max\{aime_t - aime_1, 0\} \end{aligned} \tag{8}$$

where $aime_0$ and $aime_1$ denote the bend points in the PIA formula, following rules from the Social Security Administration. This formula replaces a higher percentage of the pre-retirement earnings for workers with low average career earnings than for workers with high average career earnings.

Second, the age at which individuals apply for Social Security retirement benefits also affects the level of benefits. These effects are summarized in Table 2 in Section 3.

Third, beneficiaries under age 70 are subject to the earnings test. That is, if they receive labor income that exceeds the earnings threshold y_{ret} after they collect retirement benefits, each dollar of labor income above y_{ret} leads to a τ_{ret} dollar decrease in retirement benefits until all the benefits have been taxed away. Thus, the final amount of benefits, ss_t, that an individual receives at age t is

$$ss_t = \max\{0, ssb_t - \tau_{ret} * \max\{0, (w_t n_t - y_{ret})\}\} \quad \text{if age} < 70 \tag{9}$$

where ssb_t is the amount of PIA_t adjusted by early/delayed application for retirement benefits. Note that those benefits lost due to the RET are credited to future benefits.[22]

Individuals who are disabled, $h_t = 2$, receive Social Security disability benefits before NRA if their labor income is below a certain value y_{db}. Disability benefits db_t are calculated in the same way as retirement benefits, i.e., $db_t = PIA_t$, but there is no early penalty rate. Upon reaching the NRA, disability benefits automatically convert to retirement benefits.[23]

[22]Following French and Jones (2011), if a year's worth of benefits are withheld due to the RET between the ERA and (NRA-1), benefits in the future are increased by 6.67%, the actuarial reduction factor for early application. If a year's worth of benefits withheld due to the RET between the NRA and 70, benefits in the future are increased by DRC.

[23]Individuals in my model do not make decisions on disability benefits application. As in the literature that explicitly models Disability Insurance claims, e.g., Low and Pistaferri (2015), Li (2018), and Michaud and Wiczer (2019), the

In this study, pension benefits, pb_t, are modeled in the same way as in French (2005),

$$pb_t = pb(PIA_t) \tag{10}$$

where pb_t is imputed as a function Social Security benefits. Similar to Social Security benefits, pb_t depends on the individual's lifetime career earnings and is illiquid until age 62. Unlike Social Security benefits, pb_t is not affected by early/delayed Social Security application and earnings test, and pension accrual rates are higher in the 50s and lower at other ages for individuals. These are all captured and adjusted in modeling pension benefits. See French (2005) for more details.

4.5. ***Budget Constraint***

In each time period, an individual receives income through interest on assets, ra_t; labor income, $w_t n_t$; spousal earnings, ys_t; pension benefits, pb_t; Social Security retirement benefits net of the earnings test (if applicable), ss_t; Social Security disability benefits (if applicable), db_t, and government transfers (if applicable), tr_t. The budget constraint faced by a household head is given by:

$$\begin{aligned} a_{t+1} =& a_t + Y_t(y_t, \tau_t, \tau_t^{ss}) + (b_t * ss_t) + db_t \mathbb{1}_{\{h_t=2\}} + tr_t - m_t - c_t \\ & y_t = ra_t + w_t n_t + ys_t + pb_t \\ & Y_t(y_t, \tau_t, \tau_t^{ss}) = y_t - T_t(y_t, \tau_t) - T_t^{ss}(w_t n_t, \tau_t^{ss}) \end{aligned} \tag{11}$$

The variable $b_t \in \{0, 1\}$ is an indicator variable that takes a value one if the individual has claimed the retirement benefits and zero otherwise. The term y_t is the annual taxable income in period t, where r is the pre-tax risk-free interest rate; $T_t(\cdot)$ presents taxes paid on income in period t, which is a function of taxable income y_t and tax rate τ_t; and T_t^{ss} denotes the payroll tax paid on labor income, which depends on labor income $w_t n_t$ and tax rate τ_t^{ss}. Let $Y_t(\cdot)$ denote the after-tax income. Details of taxes are in Section 4.6.

Individuals also face the borrowing constraint,

$$a_{t+1} \geq 0. \tag{12}$$

It is illegal to borrow against Social Security benefits and difficult to borrow against most forms of pension wealth.

Government transfers, tr_t, provide a consumption floor $\underline{c}$, as in Hubbard et al. (1995) and

probability of applying for disability insurance successfully depends on age and health status. To capture the probability and average disability benefits received by disabled individuals, I assume the benefit level db_t that the eligible disabled people can receive is discounted by π^{db}, where π^{db} is the probability taken from Low and Pistaferri (2015) for old age groups with severe work limitation.

De Nardi et al. (2010), such that

$$tr_t = \min\{0, \underline{c} + m_t - (a_t + Y_t + ss_t + db_t)\}. \tag{13}$$

They imply that individuals can consume at least at a minimum level, $\underline{c}$, which captures the federal safety net programs in the United States, such as Food Stamps and Supplemental Security Income, etc.[24]

*4.6. **Taxes***

Individuals in a cohort face the effective time-varying income tax rate over their life cycle. As in Bénabou (2002) and Borella et al. (2019a), effective tax rates depend on age (time) and taxes paid on annual income y_t are given by:

$$T_t(y_t, \tau_t) = (1 - \lambda_t y_t^{-\tau_t}) * y_t \tag{14}$$

where y_t is from Equation (11); τ_t denotes the degree of progressivity; and λ_t denotes the average level of taxation. For tractability, I assume that individuals anticipate changes in the effective tax rates on total income.

Moreover, workers pay the payroll taxes on labor income to help finance Social Security and Medicare, hence, there is a payroll tax rate τ_t^{ss} on the worker's labor income $w_t n_t$, up to a threshold $\bar{y}_t^{ss}$ in each period. Then the amount paid for the payroll tax at age t are given by:[25]

$$T_t^{ss}(w_t n_t, \tau_t^{ss}) = \tau_t^{ss} * \min[w_t n_t,\ \bar{y}_t^{ss}] \tag{15}$$

*4.7. **Recursive Formulation***

The life cycle can be divided into three stages for each individual. The first stage is between ages 25 and 61: individuals are not eligible for pension and Social Security retirement benefits and only decide on consumption and hours worked (including participation). Let $X_t = (a_t, w_t, h_t, aime_t)$ denotes the vector of state variables at age t, it includes: asset, a_t; wage, w_t; health and disability status, h_t; and Social Security wealth, $aime_t$. Since spousal earnings, out-of-pocket medical expenditure, and pension benefits depend on other state variables, they are not

[24]Braun et al. (2017) and Kopecky and Koreshkova (2014) explicitly model the means-tested social insurance programmes that provide agents with a guaranteed minimum level of consumption, such as Supplemental Security Income and Food Stamp programs.

[25]I do not model the budget for the government because I consider only one cohort, and it is unclear that whether the budget constraint is balanced at the cohort level.

included in X_t explicitly. In recursive form, the individual's problem in state (X) and age t can be written as:

$$\begin{aligned} V_t(X_t) &= \max_{c_t,n_t}\{u(c_t,l_t) + \beta s_{t+1}E_t[V_{t+1}(X_{t+1})] + \beta(1-s_{t+1})B(a_t)\} \\ &= \max_{c_t,n_t}\{\frac{1}{1-\nu}(\, c_t^{\gamma}\, [L_t - n_t - \theta_p^{h_t}p_t - \phi\mathbb{1}_{\{h_t\neq 0\}}]_t^{1-\gamma}\,)^{1-\nu} \\ &\quad + \beta s_{t+1}\int V_{t+1}(X_{t+1})dF(X_{t+1}|X_t,t,c_t,n_t) + \beta(1-s_{t+1})B(a_{t+1})\} \end{aligned} \tag{16}$$

subject to Equations (3)-(15). The parameter β is the discount factor. Individuals with higher values of β are more patient and more willing to defer their consumption and leisure. The function $F(\cdot|\cdot)$ determines the conditional distribution of state variables, given (3)-(15).

When an individual dies, any remaining assets, a_t, are left to his heirs. Following De Nardi (2004), an individual who dies values bequest of the leftover assets, a_t, according to a bequest function $B(a_t)$, which takes the form:

$$B(a_t) = \theta_b\frac{(a_t+\kappa)^{(1-\nu)\gamma}}{1-\nu} \tag{17}$$

The parameter θ_b is the bequest weight and determines the strength of the bequest motive. It determines the marginal propensity to consume out of wealth in the final period of life. The term κ is the bequest shifter and measures the curvature of the bequest function. Individuals with a higher value of κ treat the bequest more like a luxury good. There is infinite disutility of leaving non-positive bequests if $\kappa = 0$, while the utility of a zero bequest if finite if $\kappa > 0$.[26]

The second stage is between ages 62-69, a transition period where individuals choose consumption, labor supply, and whether to apply for Social Security retirement benefits. The value function of the individual in state (X_t) is described as:

$$\begin{aligned} V_t(X_t) = \max_{c_t,n_t,b_t}\{&\frac{1}{1-\nu}(\, c_t^{\gamma}\, [L_t - n_t - \theta_p^{h_t}p_t - \phi\mathbb{1}_{\{h_t\neq 0\}}]_t^{1-\gamma}\,)^{1-\nu} \\ &+ \beta s_{t+1}\int V_{t+1}(X_{t+1})dF(X_{t+1}|X_t,t,c_t,n_t,b_t) \\ &+ \beta(1-s_{t+1})B(a_{t+1})\} \end{aligned} \tag{18}$$

subject to Equations (3)-(15). The state vector is $X_t = (a_t, w_t, h_t, b_{t-1}, aime_t)$, and the indicator b_{t-1} denotes Social Security benefits claim status.

[26] French and Jones (2011) show that the bequest parameters θ_b and κ are identified largely from the top asset quantile. When κ is large, the marginal utility of bequests will be lower than that of consumption, unless the individual is rich.

The third stage is between ages 70-95, an entire retirement period where individuals only decide on consumption. Since Social Security rules provide no incentive to delay retirement benefit application after reaching age 70, I assume that all workers retire and apply for Social Security benefits by age 70, i.e., for $t \geq 70, b_t = 1, n_t = p_t = 0$. Then the individual's value function during the entire retirement period is given as follows:

$$
\begin{aligned}
V_t(X_t) = \max_{c_t}\{&\frac{1}{1-\nu}(c_t^{\gamma} \, [L_t - \phi \mathbb{1}_{\{h_t=1\}}]_t^{1-\gamma})^{1-\nu} \\
&+ \beta s_{t+1} \int V_{t+1}(X_{t+1}) dF(X_{t+1}|X_t, t, c_t) + \beta(1 - s_{t+1}) B(a_{t+1})\}
\end{aligned}
\tag{19}
$$

subject to Equations (3), (6)-(14). The vector of state variables is $X_t = (a_t, h_t, aime_t)$.

The model is solved backwards using value function iteration. An individual's decisions in period t depend on his state variables X_t, preferences $\Theta = (\gamma, \nu, \theta_p^{h=0}, \theta_p^{h\neq 0}, \phi, L, \beta, \theta_b, \kappa)$, and parameters that determine the data generating process for the state variables $\chi = (r, \sigma_\eta^2, \rho, W(h_t, t + 1), \{\pi_{h_{t+1},h_t,t}\}_{t=1}^T, \{s_t\}_{t=1}^T, \{ys_t\}_{t=1}^T, \{m_t\}_{t=1}^T, \{pb_t\}_{t=1}^T, \{ss_t\}_{t=1}^T, \{db_t\}_{t=1}^T, Y_t(\cdot))$.

The solution to a male household head's problem consists of sequences of consumption rules $\{c_t(X_t, \Theta, \chi)\}_{1\leq t\leq T}$, hours worked rules $\{n_t(X_t, \Theta, \chi)\}_{1\leq t\leq T}$, and Social Security benefit application rules $\{b_t(X_t, \Theta, \chi)\}_{1\leq t\leq T}$ that solve problems (16)-(19). The labor force participation rules at t, $p_t(X_t, \Theta, \chi)$, are equal to zero when $n_t(X_t, \Theta, \chi) = 0$ and equal to one otherwise. Assets in the next period, $a_{t+1}(X_t, \Theta, \chi)$, can be obtained by inserting these decision rules into the asset accumulation equation (11). See Appendix D for more details on my computations.

5. Estimation

I estimate my model using a two-step Method of Simulated Moments (MSM) estimation strategy, as standard in the literature, e.g., Gourinchas and Parker (2002), Cagetti (2003), French (2005), and Haan and Prowse (2014). In the first step, I estimate or calibrate the parameters that can be cleanly identified without explicitly using my model, χ, including health transitions, survival probabilities, out-of-pocket medical spending, spousal earnings, wage profiles, wage process, the interest rate, consumption floor, and initial distributions of state variables, such as savings, AIME, and health status. I estimate those parameters directly from the data, set some of them using the existing literature evidence, and compute some of them from program rules.

In the second step, taking the parameters that were estimated in the first step χ as given, I use the Generalized Method of Moments (GMM) techniques to estimate the remaining preference parameters: $\Theta = (\gamma, \nu, \theta_p^{h=0}, \theta_p^{h\neq 0}, \phi, L, \beta, \theta_b, \kappa)$, which include the consumption weight, risk aversion, cost of working and time endowment for healthy and unhealthy people, discount factor, and bequest parameters. The objective is to find a vector of parameters Θ that generates simulated decision profiles that *best match* (measured by a GMM criterion function) the corresponding profiles from the data. In this paper, I require my model to match the life-cycle profiles of participation, hours worked conditional on participation, and savings by health from the PSID for the 1930s cohort. The following sections describe these two steps in more detail.

5.1. ***First-Step Estimation***

I primarily use two data sets for estimating the parameters in the first step: the Panel Study of Income Dynamics (PSID) and the Medical Expenditure Panel Survey (MEPS). Moreover, I borrow the parameters for the consumption floor ($\underline{c}$) and the pre-tax interest rate (r) from French (2005).[27] I compute the Social Security program related parameters using the information from the Social Security Administration. Table 3 provides a summary of the first-step inputs.

5.1.1. ***Data***

The PSID is a longitudinal study of a representative sample of the U.S. population. The study began in 1968 with a nationally representative sample of 18,000 individuals belonging to 5,000 families. Researchers interviewed these individuals and their descendants on an annual basis (biennial since 1997), collecting information on, among other things, labor market behaviors, income, health status, and wealth. I use the 1968-2015 waves of PSID to construct my sample of American men. The resulting sample comprises 984 individuals and 20,091 observations.

The MEPS is a nationally representative survey of families, individuals, their medical providers and employers across the United States. It provides very detailed data on medical expenditures, sources of payment, health insurance coverage, health status, and demographic and socio-economic characteristics. I use data from the 1999–2012 waves of MEPS to estimate the profiles of medical expenditure. I drop the observations with missing values of relevant variables, e.g., age, medical spending, or health insurance. The resulting sample comprises 120,731 persons and 211,709 person-year observations. See Appendix A for more information on data and my sample selection.

[27] In addition to fixing the interest rate, I tried computing time-varying interest rates faced by the 1930s cohort using the procedure adopted in De Nardi et al. (2010). I computed the real return over the years 1976-2016 using returns from stock (adjusted using S&P 500 indexes), CD, bond, and housing (adjusted using FHFA). The computed time-varying interest parameters did not change the estimation results.

Table 3: First-Step Parameters Summary

Parameter	Description	Value		Source
Budget Constraints				
r	Real interest rate	4%		French (2005)
$ys(\cdot)$	Spousal earnings	text		PSID
$\underline{c}$	Consumption floor	\$3,500		French and Jones (2011)
$aime_t$	Social Security wealth	text		SSA
ss_t	Social Security retirement benefits	text		SSA
db_t	Social Security disability benefits	text		SSA
pb_t	Pension benefits	text		French (2005)
Wage-Related Parameters				
$W(\cdot)$	Deterministic wages	text		PSID
ρ	Autoregressive coefficient	0.981		PSID
σ_ρ^2	Variance of innovation	0.0157		PSID
Mortality and Health Transitions				
s_{t+1}	Survival probabilities	text		PSID
$\pi_{h_t,h_{t-1},t}$	Health transitions	text		PSID
$m(\cdot)$	Out-of-pocket medical expenses	text		MEPS
Tax Related Parameters				
τ_t, λ_t	Income tax structure	text		PSID, Borella et al. (2019a)
τ_t^{ss}	Payroll tax rate	text		SSA
$\bar{y}_t^{ss}$	Threshold, payroll tax	text		SSA
Social Security Rules Related Parameters				
y_{db}	Disability benefits income test	\$3,600		SSA
$aime_0$	1st bend point in PIA formula	\$3,720		SSA
$aime_1$	2nd bend point in PIA formula	\$22,392		SSA
$aime_{max}$	Maximum Social Security wealth	\$43,800		SSA
ERA	Early retirement age	62		SSA
NRA	Normal retirement age	65		SSA
DRC	Delayed retirement credits	4.5%		SSA
	Retirement Earnings Test	Under NRA	NRA-69	
τ_{ret}	Tax rate	50%	33%	SSA
y_{ret}	Threshold	\$6,000	\$8,186	SSA

[1] Notes: Monetary values are expressed in 1987 dollars.
[2] Abbreviation: ERA = Early Retirement Age; NRA = Normal Retirement Age; DRC = Delay Retirement Credit.
[3] Data Source: Medical Expenditure Panel Survey (MEPS), Social Security Administration (SSA), and Panel Study of Income Dynamics (PSID), author's calculations.

5.1.2. **Health Transitions**

Health and disability status is measured based on the following set of self-reported work limitation questions from the PSID.[28] Respondents in year t report (1) *Do you have any physical or nervous condition that limits the type of work or the amount of work that you can do*? (2) *Does this condition keep you from doing some types of work*? (3) *For work you can do, how much does it limit the amount of work you can do – a lot, somewhat, or just a little*?

Following Low and Pistaferri (2015), I define those who are in good health ($h_t = 0$) as anyone who reports "No" to the first question or "Not at all" to the third question; those who are in bad health ($h_t = 1$) as anyone who reports "Yes" to the first question and "Somewhat" or "Just a little" to the third question; and those who are in a disabled state ($h_t = 2$) as anyone who reports "Yes" to the first question, "Can do nothing" to the second questions, and "A lot" to the third question, which intends to meet the SSA criterion on disability insurance qualification.[29]

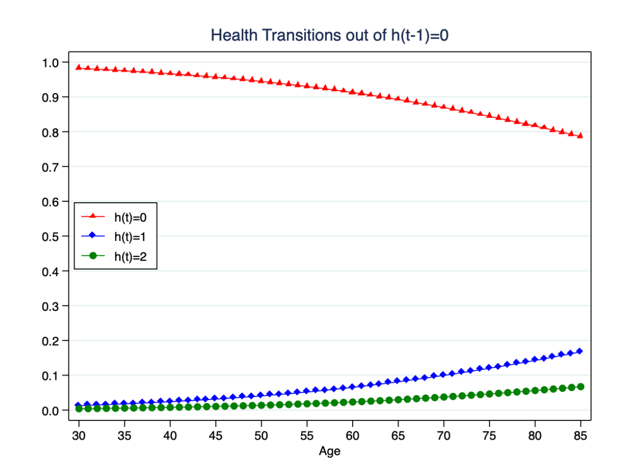


Fig. 3. Health Transitions - The probabilities of transitioning out of good health: $Pr(h_t|h_{t-1} = 0)$

Notes: The red line shows the transition probabilities from good health to good health $Pr(h_t = 0|h_{t-1} = 0)$. The blue line shows the transition probabilities from good health to bad health $Pr(h_t = 1|h_{t-1} = 0)$. The green line shows the transition probabilities from good health to disability status $Pr(h_t = 2|h_{t-1} = 0)$.

Source: Panel Study of Income Dynamics, author's calculations.

[28]Alternatively, Hosseini et al. (forthcoming) construct frailty index to measure health status over the life cycle, using the PSID survey questions on health conditions, which have been available since 2003. However, their health measurement cannot be adopted in this paper because I focus on the life-cycle health dynamics for the 1930s cohort, and thus, those PSID survey questions are not feasible.

[29]The possible answers to the first question are (1) Yes or (2) No; the possible answers to the second question are (1) Yes, (2) No, or (3) Can do nothing; the possible answers to the third question [after 1976] are (1) Not at all, (2) Somewhat, (3) Just a little, or (4) A lot; and the possible answers to the third question [before 1976] are (1) I can't work, (2) It limits me a lot, (3) Some, not much, or (4) Limitation, but not on work. Since the second question became available from 1986, before that, I define the health status only based on the first and third questions.

Since there are three health states, $h_t = \{0, 1, 2\}$, we have nine transition patterns, $Pr(h_t = j|h_{t-1} = i)$, $i, j \in \{0, 1, 2\}$. I estimate the evolution of health for individuals in the 1930s cohort by running a probit regression for an indicator $(h_t = j|h_{t-1} = i)$ on age dummies using the sample with $(h_{t-1} = i)$. The predicted values of these probit regressions are the estimates of $Pr(h_t = j|h_{t-1} = i)$, $i, j \in \{0, 1, 2\}$. I linearly interpolate the probabilities of transitioning in three states across ages so that the transition matrices changes smoothly over the life cycle. Figure 3 displays the age-specific health transition out of good health status $Pr(h_t|h_{t-1} = 0)$, and the remaining transitions are reported in Figure G.2 in Appendix G.

As shown in Figure 3, the probabilities of staying healthy decline over the life cycle, and the drop is more rapid at older ages. For instance, the probability of staying in good health decreases from 99% at age 30 to 90% around age 65 and 80% around age 80. The decline is mostly absorbed by increasing probabilities of transitioning into bad health, which increase with age, and the increase is faster at older ages.

5.1.3. **Survival Probabilities**

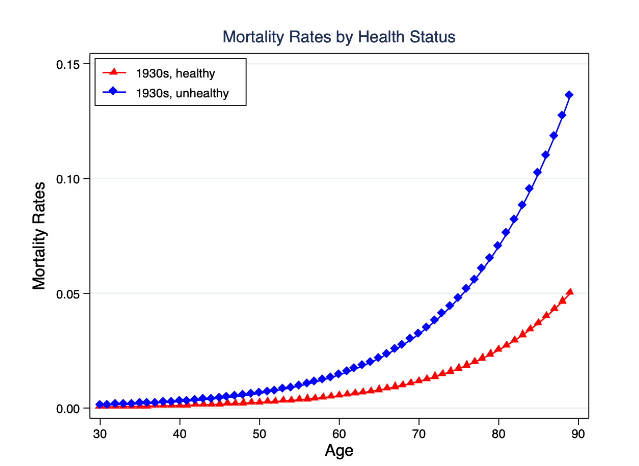


Fig. 4. Mortality Rates by Health Status

Notes: The blue line shows the probability of dying next period when unhealthy. The red line shows the probability of dying next period when healthy.
Source: Panel Study of Income Dynamics, author's calculations.

Age- and health-dependent survival probabilities are estimated by running a logistic regression for the indicator of survival on age polynomial, previous health status, and interaction between cohort dummies and these variables whenever they are statistically significant, using data from the

PSID. The estimated coefficients are reported in Table F.1 in Appendix F.[30] Figure 3 displays the estimated mortality rates by age and health status.[31]

Mortality rates increase over the life cycle for both healthy and unhealthy types. The increase is extremely quick for the unhealthy type at older ages, even though healthy and unhealthy types start from very similar levels.

5.1.4. **Out-of-Pocket Medical Expenses**

The out-of-pocket medical expenses are computed as total medical expenditure net of the amount covered by health insurance programs, using data from the MEPS. Health status is measured based on self-perceived health rank (e.g., Pashchenko and Porapakkarm (2019)), which ranges from 1 to 5.[32] I estimate the out-of-pocket expenditure in the following steps.

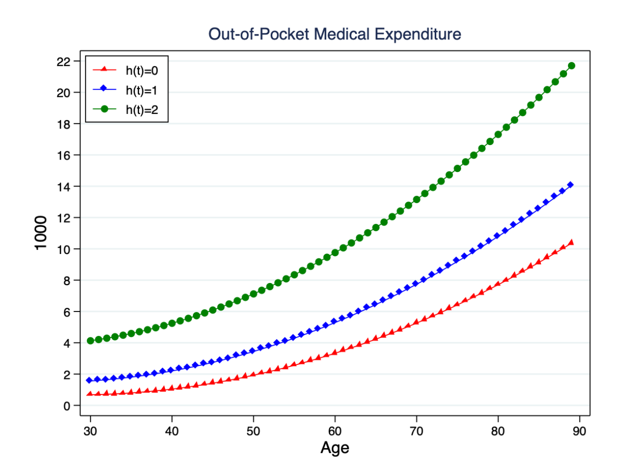


Fig. 5. Out-of-Pocket Medical Expenditure by Health Status

Notes: The red line shows the out-of-pocket expenditure for people in good health. The blue line shows that for people in bad health. The green line shows that for people in disabled state. Monetary values are expressed in 2016 dollars. Source: Panel Study of Income Dynamics, author's calculations.

First, I estimate the profiles of total medical expenditure by running a weighted regression on

[30]Due to the small sample size of joint event ($s_t = 0|h_{t-1} = 2$), I assume that unhealthy individuals ($h = 1, 2$) face the same survival/mortality rates at each age.

[31]As French (2005) discussed, the PSID underestimates mortality rates by 25%. I adjusted my estimated mortality rates by multiplying 1.25 for my model estimation.

[32]The MEPS survey has three waves in each year t, and in each wave respondents rank their health as (1) *excellent,* (2) *very good,* (3) *good,* (4) *fair, or* (5) *poor*. Individuals whose health rank falls in the first three categories in all three waves are referred to people in good health ($h_t = 0$); individuals with health rank falls in the last category in any wave are referred to as disabled people ($h_t = 2$); and the rest are referred to as people in bad health ($h_t = 1$).

age dummies and year dummies, separately for individuals in each health status.[33] Then I estimate the profiles of coverage rates (ratio of the amount covered by insurance programs and the total medical expenditure) by regressing them on age dummies and year dummies, separately by health status. For working-age individuals (age 25-64), the medical coverage is computed as the amount paid by private insurance programs or Medicaid. In contrast, for individuals who are 65 or older, the coverage is calculated as the expenses paid by Medicare. Next, I compute the out-of-pocket expenditure as the product of estimated un-coverage rates and total medical expenses at each age and health status.[34] Last, I smooth my estimated profiles by regressing them on a quadratic function of age.

Figure 5 displays the smoothed life-cycle profiles of the out-of-pocket medical expenses by health status. The difference in medical cost by health is sizable. For example, at age 80, the average annual out-of-pocket medical expenses are about \$17,000 for disabled people, which are \$6,000 higher than those for people in bad health and \$9,000 higher than those for people in good health.

5.1.5. **Hourly Wages**

Individuals' work decisions are strongly affected by their life-cycle wage profiles. As described in the model section, the deterministic wage profiles $W(h_t, t)$ depend on the individual's age and health. In particular, unhealthy people typically have lower wages than healthy people.

Hourly wages are computed as annual earnings divided by annual hours worked, using data from the PSID. Respondents in year t report their annual earnings and hours worked in year $t-1$.[35] Since wages are only observed for labor market participants in the data, to adjust selection bias in observed wages, I estimate hourly wage profiles using the two-stage Heckman selection model (Heckman (1976)), as used by Guner et al. (2012) and Bairoliya (2019).[36] In the first step, I estimate the labor force participation (selection equation) by running a probit regression using all observations from the PSID, and an inverse Mill's ratio is generated. In the second step, I estimate hourly wage by running a regression on age polynomials, the intersection of health and age

[33]Following the procedure used by Pashchenko and Porapakkarm (2019), I use the cross-sectional weights and longitudinal weights provided by MEPS in the estimation.

[34]Following De Nardi et al. (2018), the estimated medical expenses are multiplied by 1.60 for people younger than 65 years old and by 1.90 for people who are 65 or older to make medical spending consistent with the aggregate medical expenditures from the National Health Expenditure Account (NHEA).

[35]I drop the observations with hourly wages below \$6.50 or above \$250 (in 2016 dollars) to control the minimum wage and high wage outliers, similar to the sample selection used by French (2005) and Borella et al. (2019b) for estimating wage profiles.

[36]To adjust the selection bias problem in observed wages, French (2005) adapted a procedure by assuming that the fixed-effects wage profiles of workers from the data and the model simulation have the same bias problem.

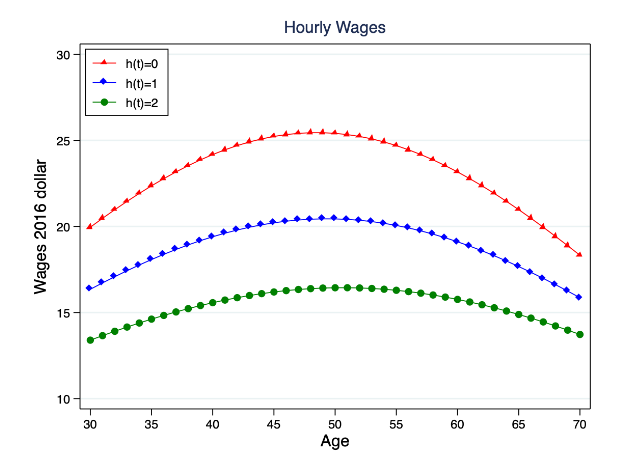


Fig. 6. Hourly Wages by Health and Disability Status

Notes: The red line shows the hourly wages for people in good health. The blue line shows those for people in bad health. The green line shows those for people in disabled state. Monetary values are expressed in 2016 dollars.
Source: Panel Study of Income Dynamics, author's calculations.

polynomials, and the inverse Mill's ratio obtained from the first step. The estimated coefficients of the two-stage procedure are reported in Table F.2 in Appendix F.

Figure 6 displays smoothed wage profiles by health status. Several features are worth noticing. First, hourly wage rates peak for men around age 50. Second, the hourly wage rates of people in good health are higher than those of people in bad health, which are higher than those of disabled people, over the life cycle. For example, around age 50, a healthy individual's hourly wages are \$5 higher than those of people in bad health and \$9 higher than those of disabled people.

I estimate the stochastic components of hourly wages – the autoregressive coefficient and variance of wage shocks (ρ, σ_ρ^2), using the wage residuals from the above steps. Following the procedure described in Borella et al. (2019b), I limit the age range between 30 and 75 and drop the highest 0.5% residuals to avoid large outliers that inflate the variance. The estimation process is performed by Maximum Likelihood and standard Kalman Filter recursions. The estimated results for (ρ, σ_ρ^2) in wages are (0.99, 0.0125), which are consistent to the estimates of French (2005) and Borella et al. (2019b).

The estimated stochastic components of wages and deterministic age- and health-specific profiles are used in Equation (4) of the Model Section 4 to simulate wages and fed into the model estimation.

5.1.6. **Spousal Earnings**

Spousal earnings are defined as annual earnings from the PSID. Respondents in year t report their wife's total annual earnings in year $t-1$. I estimate $ys(\cdot)$ by running a fixed-effects regression on male household head's age polynomial, logarithm hourly wages, and health and disability status.[37] The estimated coefficients are reported in Table F.3 of Appendix F.

5.1.7. **Social Security Policy Rules and Taxes**

From the Social Security Administration, individuals in the the 1930s cohort face the ERA of 62, NRA of 65, DRC of 4.5% on average, bend points in the PIA formula $3,720 and $22,392, and the maximum AIME of $43,800.[38] The tax rate and exempt amount of earnings test are different for the following two age groups under age 70. 1). For Social Security beneficiaries under age 65, $1 in retirement benefits will be withheld for each $2 of labor income above the annual exempt amount, $6,000. 2). For beneficiaries aged 65 and over, $1 in benefits will be withheld for each $3 of labor income above the exempt amount, $8,186.

For disability benefits, I assume that disabled individuals can receive the disability benefits if they are over age 50 and their labor income is less than $3,600. This assumption captures the monthly substantial gainful activity amount of $300, which the SSA sets for the non-blind disabled people to be eligible for the disability benefits.

Further, individuals have to pay federal tax and payroll tax on total income and labor income. The effective time-varying marginal tax rates on American men's total income are estimated using data from the PSID for the 1930s cohort (see, e.g., Borella et al. (2019a)). For the time-varying payroll tax rates and threshold values on labor income, I take the tax rates for Social Security's Old-Age, Survivors, and Disability Insurance (OASID) and for Medicare's Hospital Insurance (HI) using data from the SSA. From 1960 to now, the sum of OASID and HI tax rates for each employee and employer varies from 3% to 7.65%.

5.1.8. **Initial Distribution**

To compute the initial distribution of the relevant state variables at age 30, I take random draws from the empirical joint distribution of wages, health, and household assets for male household heads aged 28-32 from the PSID data for the 1930s cohort. I adjust the mean of log

[37] To estimate the average profiles, I treat wife's earnings as zero for individuals who are single.

[38] Monetary values are expressed in 1987 dollars. The DRC faced by the 1930s cohort varies from 3% to 6%, depending on the year of birth. I take the average DRC, 4.5%, into my model estimation. The bend points in the PIA formula and the maximum AIME are taken from the rules of 1987.

wages for good health, bad health, and disabled state to match the estimated wage profiles for each health status. For initial Social Security wealth $aime_{30}$, I assume that all individuals enter the labor market at age 25 and work 2,000 hours per year at the hourly wage rate of age 30 to impute for initial values of AIME, following the procedure used by French (2005). Table F.4 in Appendix F summarizes the initial distribution of assets, wages, and health status. It shows that individuals in good health have higher wages and assets than those in bad health and disability status.

5.2. **Second Step Estimation**

In the second step, I use GMM techniques to estimate the remaining nine preference parameters: $\Theta = (\gamma, \nu, \theta_p^{h=0}, \theta_p^{h=1,2}, \phi, L, \beta, \theta_b, \kappa)$, and find a vector of preference parameters $\hat{\Theta}$ that minimizes the weighted distance between the estimated target profiles from the PSID and the simulated profiles generated by the model. The MSM estimator $\hat{\Theta}$ is given by the minimized GMM criterion function:

$$\hat{\Theta} = \arg\min_{\Theta} \frac{I}{1+\tau} \hat{\varphi}(\Theta;\chi)' \hat{\mathbf{W}}_I \hat{\varphi}(\Theta;\chi) \tag{20}$$

where τ is the ratio of the number of observations to the number of simulated observations and $\hat{\varphi}(\Theta;\chi)$ is a $6\mathbb{T}$-element vector of moment conditions, such that

$$\hat{\varphi}(\Theta;\chi) = \begin{bmatrix} E[p_{iht}|h,t] - \int p_t(X,\Theta,\chi) dF_{h,t}(X|h,t) \\ E[n_{iht}|h,t] - \int n_t(X,\Theta,\chi) dF_{h,t}(X|h,t) \\ E[a_{iht}|h,t] - \int a_t(X,\Theta,\chi) dF_{h,t-1}(X|h,t) \end{bmatrix}_{t\in\{30,\ldots,69\}, h\in\{healthy, unhealthy\}}$$

where $E[p_{iht}|\cdot]$, $E[n_{iht}|\cdot]$, and $E[a_{iht}|\cdot]$ are estimated from the PSID, whereas $\int p_t(X,\Theta,\chi)dF(\cdot)$, $\int n_t(X,\Theta,\chi)dF(\cdot)$ and $\int a_t(X,\Theta,\chi)dF(\cdot)$ are generated by the model. $F_{ht}(\cdot)$ indicates the CDF of the state variables at period t given health status h. Further, the estimated weighting matrix, $\hat{\mathbf{W}}_I$, is the inverse of a $6\mathbb{T} \times 6\mathbb{T}$ diagonal matrix, which consists of the elements of the variance-covariance matrix from the data along its main diagonal. For more information on the MSM, see Appendix E.

The moments that my model is estimated to match are shown as follows:

1. Labor force participation by health status (healthy and unhealthy) and ages (30-69), resulting in $2\mathbb{T}$ moment conditions.
2. Hours worked conditional on participation by health status (healthy and unhealthy) and ages (30-69), resulting in $2\mathbb{T}$ moment conditions.
3. Mean non-pension assets by health status (healthy and unhealthy) and ages (30-69), resulting in $2\mathbb{T}$ moment conditions.

This gives a total of $6 \times \mathbb{T} = 240$ moment conditions.

5.3. Target Profiles

The profiles of labor force participation, hours worked by workers, and savings by health status that my model is estimated to match are constructed using the data from the PSID. See Appendix C for more detailed information on the estimation of target profiles.

I estimate the target profiles by running the following fixed-effects regression:

$$\begin{aligned} Z_{it} = f_i + &\sum_{k=1}^{T} B_{gk} I\{age_{it} = k\} \times I\{h_{it} = 0\} + \sum_{k=1}^{T} B_{bk} I\{age_{it} = k\} \times I\{h_{it} \neq 0\} \\ &+ \sum_{f=1}^{F} B_f \text{familysize}_{it} + B_u U_t + u_{it} \end{aligned} \tag{21}$$

where Z_{it} represents the data observation of either assets, hours worked, or participation for individual i at age t; f_i denotes an individual-specific effect; familysize$_{it}$ is family size dummies; U_t is the unemployment rate; and $\{\{B_{gk}\}_{k=1}^{T}, \{B_{bk}\}_{k=1}^{T}, \{B_f\}_{f=1}^{F}, B_u\}$ are parameters.[39] Since the data observations with disability status are small, I combine observations in bad health with disabled states into *unhealthy* ($h_t = 1, 2$). Thus, the target profiles are only estimated by healthy ($h = 0$) and unhealthy ($h \neq 0$) status.

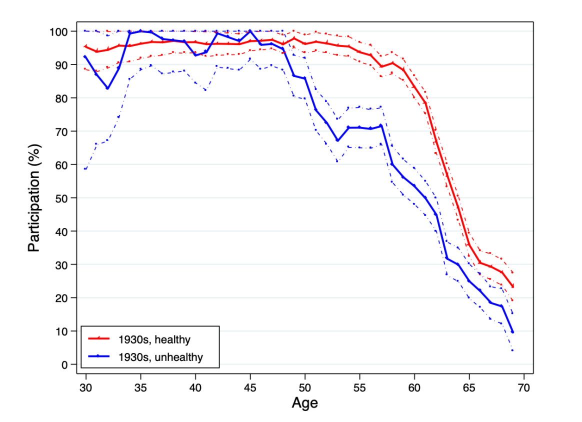
Figure 7 displays the estimated target profiles by health status. As discussed in Section 2, health has sizable effects on the life-cycle labor supply. The participation rates of healthy individuals start declining in their 60s, while those of unhealthy people begin in their late 40s (panel a). One explanation could be disability benefits provide part of unhealthy people incentives and opportunities to drop out of the labor market before the retirement age.

In Figure 7 (panel b), hours worked conditional on participation begin to decline around age 60 for both healthy and unhealthy workers. Health does not have a notable impact on annual working hours during the working period, 30-59, but it affects labor behaviors after age 60, at which workers begin working less. For example, at age 65, an average healthy worker works about 400 hours more than an average unhealthy worker.

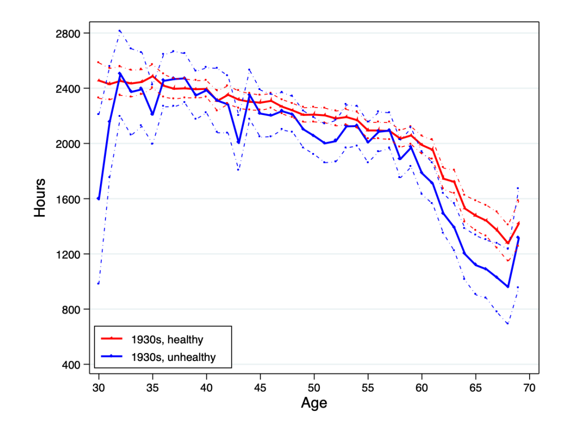
Figure 7 (panel c) shows that health has large effects on savings behaviors for individuals after age 50. An average healthy person has about \$120,000 (in 2016 dollars) more than an average

[39] To make those target profiles are not contaminated by family, year, and individual-specific effects, following French (2005), I control for family size and year (business cycle) effects by setting the family size to 3 and the unemployment rate to 6.5%. Further, I use the mean individual-specific effect for individuals who are age 50, have the average level of health at age 50, and were born in 1930, to control for birth-year (cohort) effect and correlation between person-specific effect and health status for the 1930s cohort.

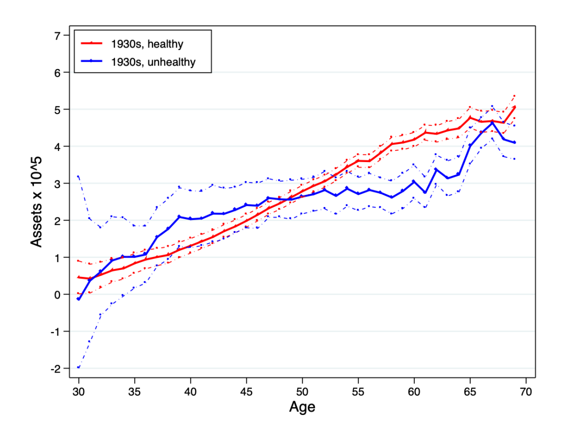
unhealthy person at age 60. Part of the difference can be explained in medical expenditure, which is more expensive for unhealthy people at older ages.



(a) Labor force participation



(b) Hours worked by workers



(c) (Non-Pension) Assets

Fig. 7. Target Profiles

Notes: Panel a shows the profiles of labor force participation by health status. Panel b shows the profiles of hours worked by health status. Panel c shows the profiles of assets by health status. The red lines represent the profiles for healthy people ($h = 0$). The blue lines represent the profiles for unhealthy people ($h = 1, 2$). Monetary values are expressed in 2016 dollars.

Source: Panel Study of Income Dynamics, author's calculations.

6. Estimation Results

To identify those preference parameters in Θ using the target profiles, as in French (2005), I assume that health status and wages are not affected by working hours decisions, as well as that preferences vary with age only due to changes in health status; that is, age changes the incentives for labor supply and savings but does not change preferences.

Table 4: Estimated Structural Parameters

Parameter	Definition	Estimates	S.E.
γ	Consumption weight	0.52	0.0034
ν	CRRA for flow utility	4.79	0.0509
β	Time discount factor	0.96	0.0030
L	Leisure endowment	5275	49.12
ϕ	Hours of leisure lost, unhealthy	102	4.36
$\theta_p^{h=0}$	Fixed cost of work, healthy	924	13.87
$\theta_p^{h=1,2}$	Fixed cost of work, unhealthy	751	12.66
θ_B	Bequest weight	0.039	0.0001
κ	Curvature of the bequest	51k	2k
χ^2 statistic (degrees of freedom = 231)		851	
Coefficient of relative risk aversion		2.97	
Labor supply elasticity, age 40, ($h = 0, h \neq 0$)		0.43, (0.43, 0.51)	
Labor supply elasticity, age 50, ($h = 0, h \neq 0$)		0.61, (0.53, 1.21)	
Labor supply elasticity, age 60, ($h = 0, h \neq 0$)		1.16, (1.01, 1.89)	

The estimated structural parameters in the second stage are displayed in Table 4.[40] My estimates are consistent with the estimation results of a large body of previous life-cycle literature, e.g., De Nardi et al. (2010) and Bairoliya (2019). My estimate of the discount factor is 0.96, which is identified by the intertemporal substitution of both consumption and leisure, and thus, by assets and labor supply profiles. My estimated CRRA for flow utility and consumption weight are 4.79 and 0.52, respectively. The CRRA for consumption be approximated as, holding the labor supply fixed, $-\frac{(\partial^2 u/\partial c_t^2)c_t}{\partial u/\partial c_t} = -(\gamma(1-\nu)-1) = 2.97$, which is identified by the assets level and labor supply profiles. The more risk averse an individual is, the more assets he accumulates to insure against the future risks, and thus, the more hours he works at younger ages to accumulate

[40] See French (2005) and French and Jones (2011) for a detailed discussion on the identification of preference parameters. Table 4 displays over-identification test statistics as well. Similar to the previous work, even though the model is formally rejected, the life cycle profiles generated by the model match closely the life cycle profiles generated by the data.

assets. This estimate is the same as in French and Jones (2011) and within the range of estimates in previous studies. Moreover, my estimation results suggest that the annual time endowments are 5,275 hours, and the hours of leisure loss due to unhealthy status, which can be identified by the fact that unhealthy individuals work fewer hours than healthy individuals, are 102 hours. They imply that unhealthy status induces about 2% loss in total available time per year, and people in bad health and disability status spend, on average, 102 hours in activities such as visiting the doctor and physical therapy, even though they are not working.

As shown in the data Section 2, the participation rates drop dramatically at older ages while hours per worker drop much more modestly. The fixed cost of working helps us capture the little labor supply variability along the intensive margin and the fact that very few people work a very small number of hours. It generates a reservation number of working hours and can be identified by the life-cycle profile of hours worked per worker.[41] As we know, unhealthy workers work fewer hours than healthy workers over the life cycle in the data. While it is often assumed to be the same for workers regardless of health status (e.g., French (2005), Bairoliya (2019)), my estimates show that the fixed costs of working for healthy and unhealthy workers are 924 and 751 hours per year, respectively. This implies that the labor market costs about 17.5% of the time for healthy people and 14.5% of the time for unhealthy people. The estimated difference in the fixed costs of working between health statuses could be interpreted as unhealthy workers preferring to work at a job with less commuting time or a part-time job with a flexible schedule. Data from the PSID shows that the annual hours traveling to work for unhealthy workers are about 80 hours less than those for healthy workers, which supports my estimation.[42]

In addition to the estimated parameters, Table 4 also reports the labor supply elasticities at ages 40, 50, and 60, as well as those values by health status, given an anticipated transitory wage increase.[43] Some key features of the elasticities are worth noting. Labor supply elasticity rises with age regardless of health status and is lower for workers in good health. Specifically, the average elasticity increases from 0.43 at age 40 to 0.61 at age 50 and further to 1.16 at age 60, which is consistent with previous studies in a similar model environment, e.g., French (2005), French and Jones (2012), and Jones and Li (2018). However, the patterns for healthy and unhealthy workers are different. The elasticity is fairly stable for the healthy workers at ages 40 and 50, and it grows

[41] Unlike having the fixed cost of working the same over the lifetime, French and Jones (2011) allow for age-varying fixed costs of working. However, health-specific and age-invariant fixed costs of working are able to make my model match age-specific and health-specific assets, employment, and hours per worker profiles well under rich social insurance structure while keeping the model framework simple.

[42] The question in the PSID is *Head's travel to work time in annual hours*.

[43] To calculate the labor elasticities at certain ages, I first use the model to simulate average work hours across all the targeted individuals in my model. Then, holding other model parameter values unchanged, I repeat the simulation with wages increasing by 20% at that age and calculate how total work hours change at each age. Table 4 reports the elasticity value in the year of wage change.

to surpass 1.0 in the early 60s; while that of the unhealthy worker is 0.51 at age 40 and begin to grow sharply in the 50s, to 1.21 at age 50 and 1.89 at age 60.[44]

The labor supply elasticities vary with age and health because of the fixed cost of working and the sensitivity of workers to the incentives generated by social insurance programs at different stages over the life cycle. At younger ages, individuals have fewer assets, and the benefits of working are typically above the cost of working. They have to work to build up a butter stock of wealth against shocks, and thus, changes in wages have little effect on their labor supply decisions. However, once they reach the 60s, payoffs generated by working decrease due to lower wages, worse health conditions, and accumulated assets, as well as accrual and work disincentives of pension and retirement benefits. As older workers are closer to the participation margin and indifferent between working and not working, their labor supply elasticities rise.[45] Though elasticities for all the health groups increase with age, workers in good health have smaller labor supply elasticities than unhealthy workers, especially in the 50s. This finding could be explained by the availability of disability insurance options for disabled workers, which provides benefits to them to leave the market. Because of the fixed cost of working, it is not optimal to work a few hours. Thus, given a large increase to current wages, their labor supply elasticities increase markedly. To the best of my knowledge, this paper is the first to quantify the extent to which labor supply elasticities change by health, accounting for both margins of labor supply.

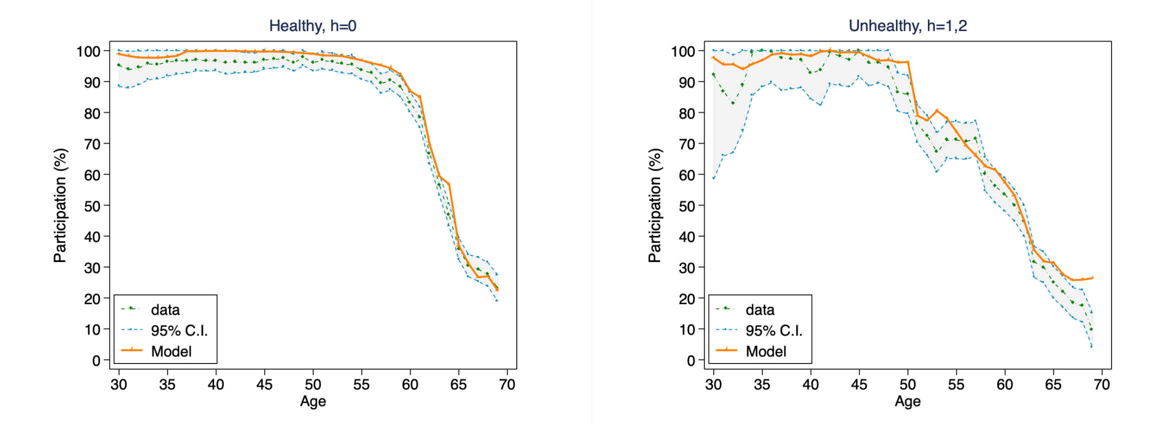
6.1. Model Fit

Figure 8 displays both the life-cycle profiles of decision variables from the PSID (including 95% confidence intervals) and from the MSM for the 1930s cohort. The model fits those targeted data profiles very well and reproduces the key observed patterns of participation, hours per worker, and savings for both healthy and unhealthy individuals over their life cycle.

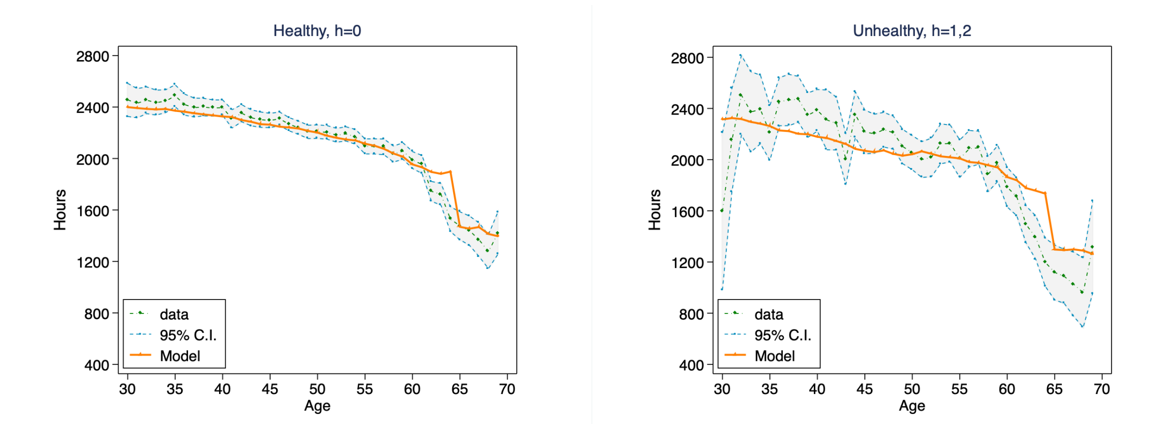
My estimated model fits the labor supply profiles of unhealthy people much closely compared to previous work, e.g., French (2005). Including disability and disability insurance is crucial for matching the declines in participation of unhealthy men before the older ages, as receiving disability benefits can be the alternative pathway to retirement for disabled people. For labor supply behaviors of individuals in both health groups, the ages at which hours per worker and participation

[44] Similarly, the elasticity patterns given a permanent wage change are also rising with age and varying with health (see Table F.5 in Appendix F).

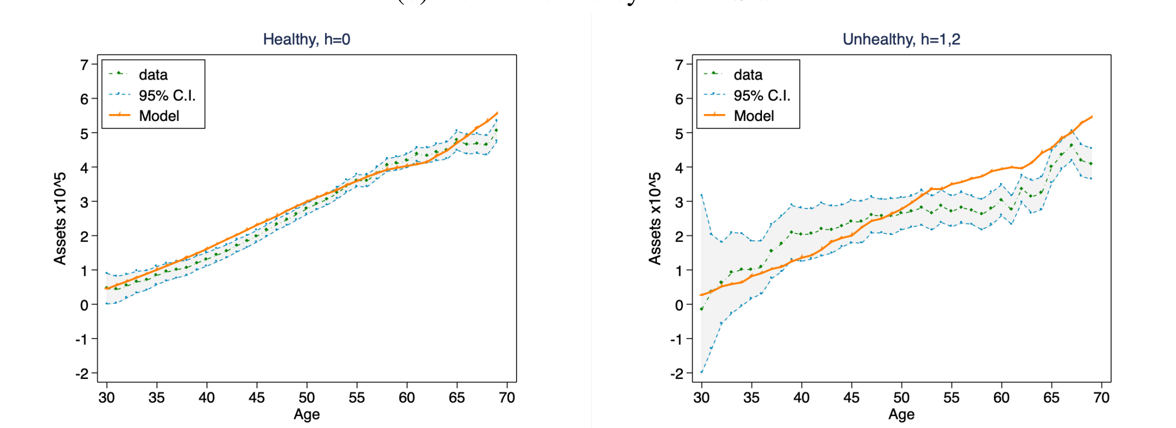
[45] Other previous studies that model human capital accumulation have also emphasized how the elasticities vary over ages and across educational groups, e.g., Keane and Wasi (2016), Keane (2016), Keane and Imai (2004), Rogerson and Wallenius (2009). In their work, younger workers are not very sensitive to changes in current wages because the human capital return is substantial for the young and is less critical at older ages. Moreover, given that human capital return is more important for more educated workers, they are relatively insensitive to the wage rate changes.



(a) Labor Force Participation by Health Status



(b) Hours Worked by Health Status

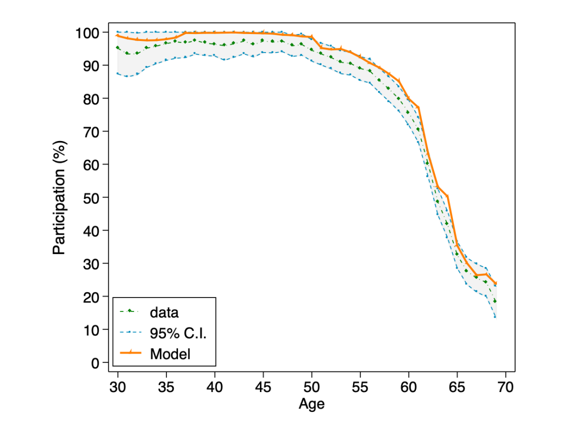


(c) (Non-Pension) Assets by Health Status

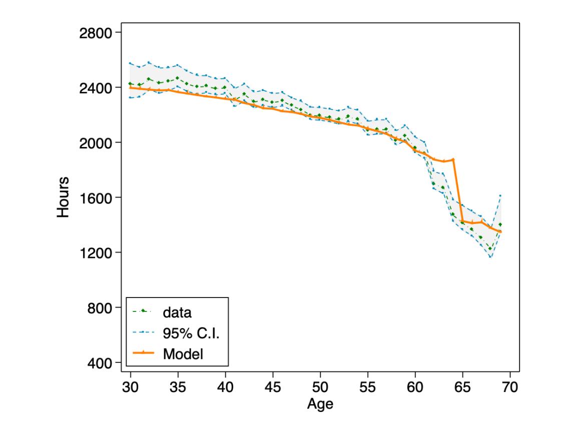
Fig. 8. Model v.s. Data Profiles: Targeted Moments

Notes: Panel a shows the model fit for labor force participation by health status. Panel b shows the model fit for hours worked conditional on participation by health status. Panel c shows the model fit for non-pension assets by health status. Profiles for healthy people ($h = 0$) are on the left, whereas profiles for unhealthy people ($h = 1, 2$) are on the right. Model profiles are represented by the orange lines. Data profiles with 95% confidence intervals are represented by the shaded area. Monetary values are expressed in 2016 dollars.

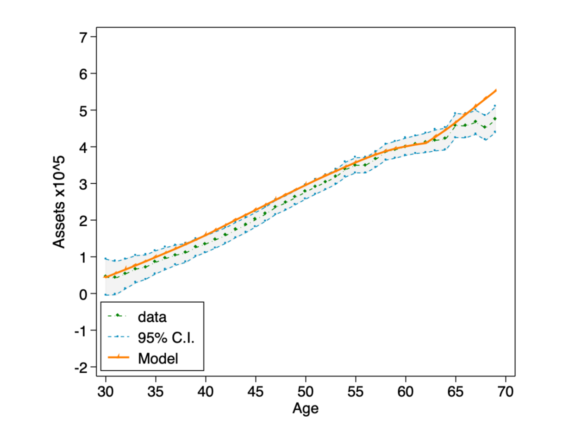
Data Source: Panel Study of Income Dynamics, author's calculations.



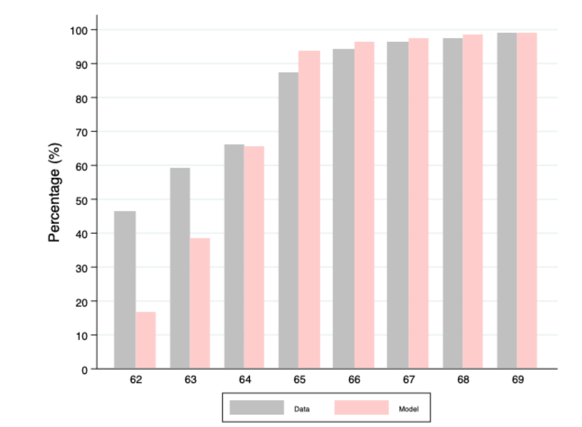
(a) Labor Force Participation



(b) Hours Worked by Workers



(c) Non-Pension Assets



(d) Cumulative Social Security Claiming

Fig. 9. Model v.s. Data Profiles: Untargeted Moments

Notes: Panel a shows the model fit for the average profile of labor force participation. Panel b shows that for hours worked conditional on participation. Panel c shows that for non-pension assets. Model profiles are represented by the orange lines. Data profiles with 95% confidence intervals are represented by the shaded area. Monetary values are expressed in 2016 dollars. Panel d shows model predictions for cumulative average Social Security retirement benefits claiming over ages.

Data Source Panel (a) – Panel (c): Panel Study of Income Dynamics, author's calculations.

Data Source Panel (d): Health and Retirement Study, Bairoliya and McKiernan (2021).

rates decline most rapidly coincide with the ages at which hourly wages fall and at which there are significant Social Security and pension work disincentives. Moreover, capturing the medical expenditure gap across different health states helps match the savings profiles by health. Individuals save against uncertainties and for retirement, and thus, matching assets for healthy and unhealthy individuals is important to evaluate the effect of policy instruments and other forces (e.g., Borella et al. (2019b)).

In addition, Figure 9 displays how my model-generated profiles fit into the untargeted profiles of individuals' behaviors. Panels (a) to (c) provide additional evidence that my estimated model accurately fits those untargeted life-cycle profiles of average labor force participation, workers' hours worked, and non-pension assets. Panel (d) plots the model-generated profile of cumulative Social Security claiming over eligible ages.[46] My model fits it quite well at age 64 and after. It captures the significant spike in claims at the NRA of 65 and nearly everyone claims after that. In the data, over 40% of people tend to claim Social Security earlier at the ERA of 62, while my model under-predicts the share of claiming at ages 62–63, similarly in other work in a similar framework, e.g., Bairoliya and McKiernan (2021). Discount factors in the early 60s discourage people from claiming retirement benefits earlier. However, the age of Social Security claiming is not equivalent to the timing of leaving the labor market. Figure 8 (panel a) and Figure 9 (panel a) show that my estimated model captures very well the labor market participation decisions overall and by health.

7. Explaining Trends in Labor Supply of Older Men

In this section, I use my estimated model from Section 6 to evaluate the extent to which the changes in the Social Security rules account for the observed rises of older workers' labor supply between the 1930s and 1950s cohorts, which are described in Section 2.[47] Taking the estimated preference parameters from the 1930s model as given, I replace the Social Security rules with those faced by the 1950s cohort and simulate how the 1930s cohort would behave if they had the same values for those factors as the 1950s cohort. Table 5 reports their effects on participation and hours worked decisions at older ages. Figure 10 displays the effects on the labor market behaviors of changing each Social Security rule and compares the model-simulated changes with the data

[46] As PSID does not have enough information on Social Security claiming, I compare my model-generated profile to the data profile that is estimated by Bairoliya and McKiernan (2021). They construct the profile using the data from the Health and Retirement Study (HRS) for the 1930s cohort.

[47] In addition to Social Security rules, health dynamics and income tax rates change across cohorts, but their effects on the labor supply are much smaller, compared to the effects of Social Security rules. See Appendix H for more information.

profiles between the two cohorts.[48]

Increasing NRA from age 65 to age 66 increases the participation and hours worked at 60-69 by 4.2% and 2.3%, respectively. As Figure 10 (panel a) displays, it only makes people stay in the labor market for one more year to be eligible to get full Social Security retirement benefits. It does not provide additional incentives for individuals to work more after reaching the new NRA. In addition, the impact on the participation decision is much smaller for unhealthy people as more healthy workers are closer to the participation margin near the NRA in the estimated model (see Figure 8). For instance, as shown in Table 5, increasing the NRA by one year causes the participation rates at 65-69 to increase by 10.4% and 1.9% for healthy and unhealthy people, respectively.

Raising the DRC from 4.5% to 8% provides incentives for workers to delay the Social Security benefits claiming after the NRA (see Figure G.5 in Appendix G), but its impact on the labor supply at older ages is negligible. It has almost no effect on labor force participation and only causes workers to work slightly more hours after 65 (see Figure 10, panel b), which increases the hours worked at 65-69 by 3.1%.

Eliminating the RET beyond the NRA is responsible for the shifts in participation and hours worked sharply upward at older ages. It increases the participation and hours worked at 60-69 by 16.1% and 10.0%, respectively. In this case, after they reach the NRA, individuals can keep their earnings from working and collect retirement benefits simultaneously without facing extra tax penalties. Thus, it incentivizes the elderly to supply labor after claiming retirement benefits beyond the NRA. As reported in Table 5, the changed earnings test rule explains the 71.1% and 86.6% observed increases in participation and hours worked by workers, respectively, from the data. Thus, eliminating the RET beyond the NRA is the main contributor to the rise in the labor supply of older workers across cohorts.

Lastly, the fifth column of Table 5 reports the effects of combining all the three documented changed Social Security rules faced by the 1950s cohort on the participation and hours worked decisions. The joint effects of three changes in Social Security rules can explain most of the labor dynamics at older ages – 73.4% of the observed rise in labor force participation and 88.7% of the observed increase in hours worked at ages 60-69 across cohorts.[49]

[48] In Appendix G, Figure G.3 and Figure G.4 display the effects on labor behaviors by health status, and Figure G.5 displays the effects on Social Security claiming behaviors.

[49] Refer to Figure G.6 in Appendix G for the displays of the effects of combining three changed rules on labor supply behaviors over the life cycle.

Table 5: Effects of Changing Social Security Rules on Labor Supply

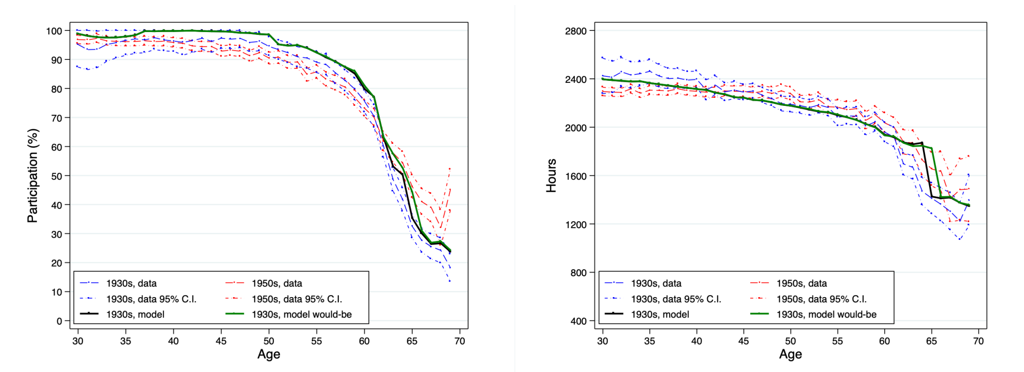
Group	Data	Model			
		NRA	DRC	RET	ALL
	(1)	(2)	(3)	(4)	(5)
% Change in Participation					
60-69					
All	22.61	4.16	0.34	16.08	16.60
Healthy	22.69	4.91	0.46	16.56	17.76
Unhealthy	14.71	1.45	-0.15	15.41	13.42
65-69					
All	58.60	8.13	1.29	54.81	51.22
Healthy	60.95	10.43	1.51	59.72	57.79
Unhealthy	40.87	1.86	0.57	42.97	34.87
% Change in Hours Worked by Workers					
60-69					
All	11.52	2.31	1.15	9.98	10.22
Healthy	10.67	2.09	1.24	9.42	9.56
Unhealthy	12.41	2.95	0.94	11.32	11.85
65-69					
All	14.55	6.08	3.14	24.64	25.73
Healthy	12.43	5.69	3.36	23.00	24.06
Unhealthy	23.25	6.77	2.44	28.44	29.16

[1] Abbreviation: NRA = Normal Retirement Age; DRC = Delay Retirement Credit (%); RET = Retirement Earnings Test.

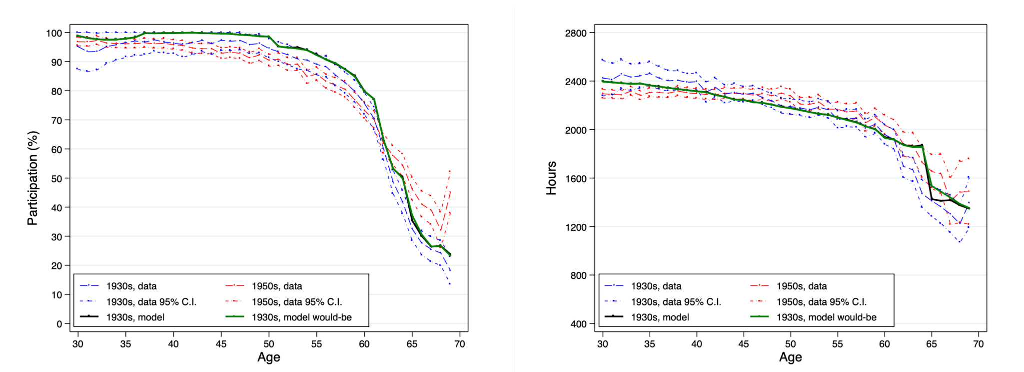
[2] Notes: Column 1 shows the % changes in participation and hours worked between the 1930s and 1950s cohorts from the data. Columns 2-5 show the model-simulated % changes in participation and hours worked after replacing the corresponding Social Security rules.

[3] Policy Experiments: Column 2: increasing the NRA from 65 to 66. Column 3: increasing the DRC from 4.5% to 8%. Column 4: eliminating the RET beyond the NRA. Column 5: changing all the three policy rules simultaneously.

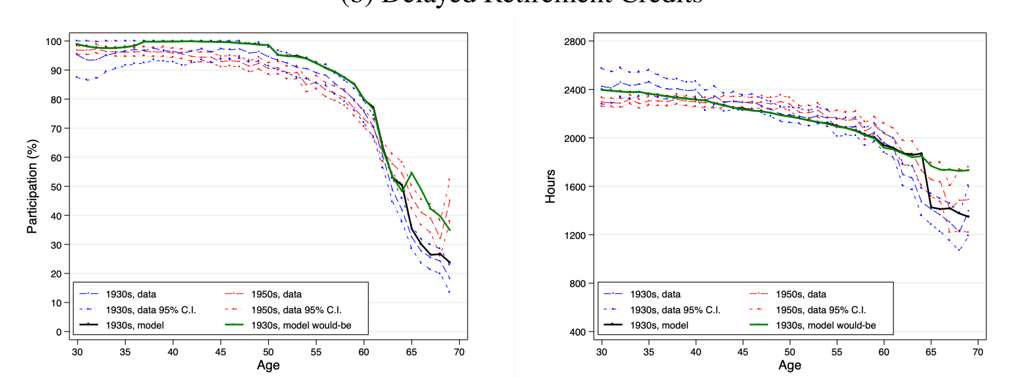
[4] Data Source: Panel Study of Income Dynamics, author's calculations.



(a) Normal Retirement Age



(b) Delayed Retirement Credits



(c) Retirement Earnings Test

Fig. 10. Model v.s. Data Profiles: Effects of Changing Social Security Rules

Notes: Effects of the corresponding policy changes on labor force participation (left panels) and hours worked by workers (right panels) at the average level. The black (green) lines show the model-simulated profiles for the 1930s cohort before (after) implementing policy changes. The blue (red) dashed lines represent the data profiles with 95% confidence intervals for the 1930s (1950s) cohort.

Policy Experiments: increasing the NRA from 65 to 66 (panel a); increasing the DRC from 4.5% to 8% (panel b); removing the RET from 70 to 65 (panel c).

Data Source: Panel Study of Income Dynamics, author's calculations.

8. Policy Experiments

Given the success of my estimated model in fitting the observed life-cycle profiles of key behaviors and explaining labor market behaviors across cohorts, I then use my model to evaluate the effects of three sets of counterfactual experiments.

The first set of experiments increases the ERA by two years, from age 62 to 64, and increases the NRA by two years, from age 66 to 68, separately. The second set of experiments is to eliminate the RET for all beneficiaries under NRA. In the third set of experiments, I increase the payroll tax rate by 1.57 percentage points and reduce retirement benefits by 23%, separately, as proposed by the 2020 Trustees Report.[50] I measure the resulting changes in simulated labor market behaviors, consumption, savings, and Social Security claiming, as well as resulting effects on the individual lifetime utility and aggregate payment to Social Security at the cohort level.[51] The effects of each experiment are summarized in columns (2)-(6) of Table 6. I compare the effects of each reform relative to the economy under the current social Security rules with the three changes described in the previous section (the first column). To isolate the reforms' effects, I keep other Social Security rules and model parameters unchanged when I conduct each policy experiment.

8.1. Shifting Retirement Age

When shifting the ERA from 62 to 64, people have to wait until age 64 to become eligible for retirement benefits, and thus, there will be fewer early benefits applicants (see Figure 11, panel a). As shown in the second column of Table 6, shifting the ERA has negligible effects on individuals' labor supply, consumption, and savings behaviors. On average, the labor force participation at 60-69 will increase but only by 0.3% (i.e., by 0.2 percentage points). These predictions are consistent with French (2005) and Imrohoroğlu and Kitao (2012), which also predict raising the ERA leaves individuals' key behaviors unchanged.

The third column shows the results of increasing the NRA from age 66 to 68. The reduction factor in the early 60s will get larger as the NRA is postponed.[52] In this case, individuals would delay Social Security application to avoid receiving greatly reduced benefits for the rest

[50] To address the solvency problem faced by the OASI Trust Funds, the 2020 Trustee Report proposes a payroll tax rate increase of 3.14 percentage points (i.e., an increase of 1.57 percentage points for each employee and employer), from 12.4% to 15.54%; or a reduction in scheduled benefits by 23% to people who become initially eligible for benefits in 2020 or later; or some combination of these approaches.

[51] Aggregate payment to Social Security is calculated as the sum of the individual's taxes paid on labor income, via the payroll tax, net of the retirement benefits or disability benefits received (after taxes or discount) over the life cycle.

[52] From the SSA, the reduction factor at age 62 is 30%, given the NRA of 67 . Since there is no available information on the reduction factor at 62 if the NRA is delayed to 68, I assume that it will be further decreased by five percentage points, to 65% at age 62.

of their lives. As Figure 11 (panel a) displays, there will be only 0.5% of individuals applying for the benefits at the ERA of 62. In addition, individuals would save more and consume less to finance their delayed benefit application. The assets at the ERA increase by 2.2%, and the average consumption decreases by 0.2%. Moreover, postponing the NRA by two years would increase the annual hours worked at older ages by 0.7% and older-age participation by 1.7% (i.e., by 0.9 percentage points). The predicted small increase in the older-age participation is consistent with that of French and Jones (2011). Compared to the predictions in Imrohoroğlu and Kitao (2012), in which raising the NRA by two years leads the participation rate at ages 60–69 to rise by 6.1 percentage points, my model predictions suggest a lower increase in the labor force participation.

8.2. Removing Earnings Test

The fourth column displays the results of eliminating the Social Security earnings test for retired workers, which means there is no extra tax penalty for people who receive earnings from working after collecting retirement benefits, even under the NRA. This reform will induce a notable increase in the fraction of early benefits application. As displayed in Figure 11 (panel b), there will be 28 percentage points more people starting to collect the benefits at the ERA. In addition, individuals will work and consume more after claiming benefits. The participation at ages 60-69 will increase by 3.4% (i.e., by 1.8 percentage points) on average, and more for unhealthy people, who will have an increase of 8.2% (i.e., 3.3 percentage points). The average consumption will be increased by 0.4%, mainly between the ERA and NRA (see Figure G.8 (panel b) in Appendix G).

8.3. Increasing Payroll Tax vs. Reducing Retirement Benefits

Finally, the fifth and sixth columns show the model-predicted results of raising payroll tax rates by 1.57 percentage points for workers and cutting Social Security retirement benefits by 23%, respectively. Both reforms lead workers to work more hours at younger ages, 30-59, and delay benefits application.

The impact of raising the payroll tax on labor supply is small. There will be a 0.2% increase in hours worked at younger ages, on average (0.2% and 0.1% for healthy and unhealthy workers, respectively). Moreover, it will discourage individuals' labor force participation, both at younger and older ages, decreasing by 0.1% and 1.4%, respectively. The decline in the labor supply induces less asset accumulation at the ERA and lower lifetime consumption, reducing by 1.5% and 0.9%, respectively. In this case, 2.5 percentage points more workers will wait until the NRA to collect the full retirement benefits instead of applying earlier and receiving discounted benefits.

Table 6: Effects of Social Security Policy Experiments

	Baseline	ERA 62→64	NRA 66→68	RET remove	Tax ↑1.57p.p.	Benefit ↓ 23%
	(1)	(2)	(3)	(4)	(5)	(6)
Participation (percentage)						
30-59	96.74	96.72	96.78	96.73	96.67	96.81
Healthy	98.32	98.30	98.34	98.30	98.29	98.36
Unhealthy	89.90	89.89	90.03	89.90	89.55	90.10
60-69	54.31	54.49	55.22	56.14	53.56	57.08
Healthy	59.08	59.26	60.99	60.31	58.32	62.28
Unhealthy	40.76	40.99	39.20	44.10	40.10	42.50
Hours worked						
30-59	2,238	2,238	2,240	2,237	2,243	2,244
Healthy	2,252	2,252	2,255	2,252	2,257	2,259
Unhealthy	2,122	2,121	2,124	2,121	2,123	2,125
60-69	1,812	1,813	1,825	1,824	1,805	1,816
Healthy	1,836	1,838	1,846	1,852	1,830	1,838
Unhealthy	1,724	1,725	1,745	1,733	1,714	1,732
Assets at 62, $100,000						
All	4.10	4.11	4.19	4.08	4.04	4.23
Healthy	4.15	4.16	4.24	4.13	4.09	4.29
Unhealthy	3.97	3.97	4.05	3.95	3.91	4.09
Consumption, $1,000						
All	49.96	49.96	49.88	50.14	49.52	49.84
Healthy	51.63	51.62	51.48	51.77	51.18	51.50
Unhealthy	41.77	41.77	41.59	42.00	41.30	41.71
Social Security Claimed (percentage)						
Early	72.34	70.03	73.40	82.17	69.77	56.8
Healthy	76.40	75.05	78.53	84.41	73.74	60.93
Unhealthy	61.90	57.10	61.34	76.4	59.55	46.17
At NRA	25.49	27.80	24.51	15.72	28.00	41.11
Healthy	21.55	22.90	19.39	13.62	24.09	37.22
Unhealthy	35.62	40.42	36.57	21.12	38.07	51.15
Delayed	2.17	2.17	2.09	2.11	2.23	2.09
Healthy	2.05	2.05	2.08	1.97	2.17	1.85
Unhealthy	2.48	2.48	2.09	2.48	2.38	2.68
Changes at the cohort level (percentage)						
Average utility value		-0.17	-0.78	-0.24	-1.00	-1.51
Aggregate SS Payment		+0.94	+7.46	-0.32	+4.34	+27.57

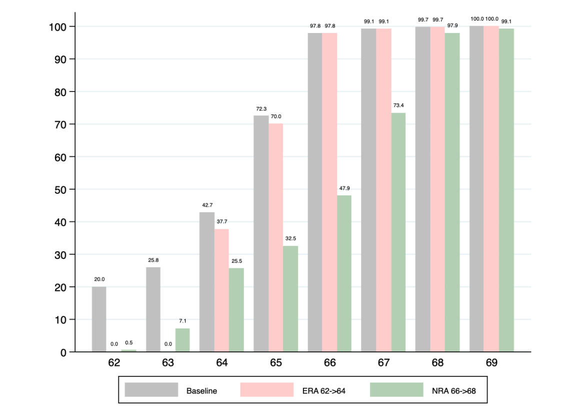
[1] Abbreviation: ERA = Early Retirement Age; NRA = Normal Retirement Age; RET = Retirement Earnings Test.
[2] Column (1): the economy with three changed Social Security rules faced by the 1950s cohort. Column (2): increasing the ERA to 64. Column (3): increasing the NRA to 68. Columns (4): eliminating the RET for beneficiaries under NRA. Column (5): increasing payroll tax rates by 1.57 percentage points (p.p.). Columns (6): reducing SS benefits by 23%.
[3] Monetary values are expressed in 2016 dollars.

Cutting retirement benefits by 23% permanently would largely reduce the individual's Social Security wealth. People have to work and save more, that is, consume and enjoy leisure less, in order to offset reduced benefits for the rest of lives. Specifically, individuals will increase the labor supply in both extensive and intensive margins over the lifetime, especially the participation at older ages, which increased by 5.1% (i.e., by 2.8 percentage points). In addition, there will be a more significant impact on the fractions of early benefits applicants, which declined by 15.5 percentage points, and the effect is larger for unhealthy individuals. Only 1.3% of unhealthy workers will claim benefits at the ERA (see Figure G.7 in Appendix G). Although cutting retirement benefits effectively reduces the tax imposed by the RET, workers will delay the Social Security claiming to avoid further reduced benefits due to early claiming. Meanwhile, the average assets at the ERA will increase by 3.2% to finance their retirement due to fewer Social Security benefits and delayed benefits application. Of the five policy experiments, cutting benefits would increase the aggregate payment to Social Security the most – by 27.57% at the cohort level, which would benefit the Social Security fund. However, on the other hand, it would reduce the individual lifetime utility the most due to less leisure and consumption.

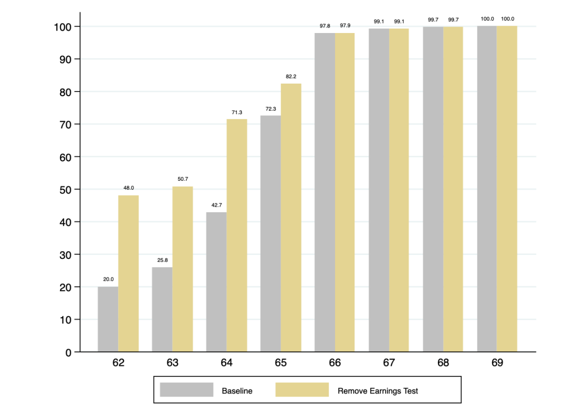
9. Conclusion

The labor supply of men over age 60 in the United States has increased from the 1930s to the 1950s cohort, in terms of both extensive and intensive margins. In addition to these notable facts, I find that the increases in the labor supply at older ages are mainly coming from people in good health. Further, Social Security rules faced by the two cohorts changed as well. For a more recent cohort, the NRA was postponed to age 66; the RET was eliminated beyond the NRA; and the DRC was raised from 4.5% to 8% on average.

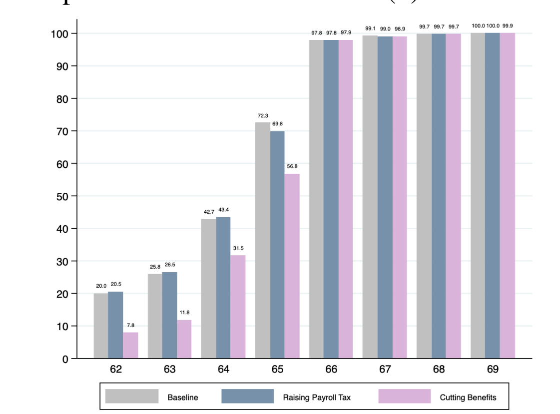
This paper develops a structural model that captures numerous details about the U.S. social insurance programs to examine the role of these documented changes in Social Security rules on the increase in the labor supply of older men across cohorts. Compared with previous studies, my model fits the labor supply and savings profiles by health status very well after incorporating heterogeneity in health and disability, health-dependent medical expenditures, and the key features of disability benefits. My model shows that the three changed Social Security rules explain most observed rises in the older-age labor supply along both margins across cohorts. Of the three changed rules, eliminating the RET beyond the NRA provided the greatest contribution to these increases. Additional policy experiments suggest that postponing the retirement age has small effects on individual behaviors, while eliminating the RET completely and reducing retirement benefits by 23% would further increase the older-age labor supply.



(a) The First Set of Experiments



(b) The Second Set of Experiments



(c) The Third Set of Experiments

Fig. 11. Policy Experiments on Social Security Application

Notes: This figure illustrates model-predicted fraction of individuals who had applied for Social Security retirement benefits at ages 62-69. The gray "Baseline" bars refer to the percentage under the economy with the Social Security rules faced by the 1950s cohort. Panel a shows the effects of the first set of experiments (increasing the ERA and NRA). Panel b shows the effects of the second set of experiments (removing the earnings test). Panel c shows the effects of the third set of experiments (increasing the payroll tax and cutting the retirement benefits).

This paper highlights the importance of Social Security changes in the earning test on the labor supply trends of older people, and it provides insight into the potential impact of future Social Security policy reforms on the individual behaviors. Applying the government retirement rules of other countries to the U.S. labor market would provide useful points of comparison and broaden the meaning of this research.

References

M. Aguiar, M. Bils, K. K. Charles, and E. Hurst. Leisure luxuries and the labor supply of young men. *Working paper*, February 2018.

O. Attanasio, H. Low, and V. Sánchez-Marcos. Explaining changes in female labor supply in a life-cycle model. *American Economic Review*, 98(4):1517–1552, 2008.

N. Bairoliya. Pension plan heterogeneity and retirement behavior. *European Economic Review*, 116:28–59, 2019.

N. Bairoliya and K. McKiernan. Revisiting retirement and social security claiming decisions. *Working Paper*, 2021.

D. M. Blau and D. B. Gilleskie. The role of retiree health insurance in the employment behavior of older men. *International Economic Review*, 49(2):475–514, May 2008.

D. M. Blau and R. M. Goodstein. Can social security explain trends in labor force participation of older men in the united states? *The Journal of Human Resources*, 45(2):328–363, Spring 2010.

M. Borella, M. De Nardi, and F. Yang. Are marriage-related taxes and social security benefits holding back female labor supply? *NBER Working Paper no. 26097*, 2019a.

M. Borella, M. De Nardi, and F. Yang. The lost ones: The opportunities and outcomes of white non-college-educated americans born in the 1960s. *NBER Macro Annual*, 2019b.

R. A. Braun, K. A. Kopecky, and T. Koreshkova. Old, sick, alone, and poor: A welfare analysis of old-age social insurance programmes. *Review of Economic Studies*, 84(2):580–612, 2017.

R. Bénabou. Tax and education policy in a heterogeneous-agent economy: What levels of redistribution maximize growth and efficiency? *Econometrica*, 70(2):481–517, March 2002.

M. Cagetti. Wealth accumulation over the life cycle and precautionary savings. *Journal of Business and Economic Statistics*, 21(3):339–353, 2003.

T. Cajner, J. Fernández-Blanco, and V. S. Marcos. Widening health gap in the U.S. labor force participation at older ages. *BSE Working Paper 1298*, November 2021.

M. Casanova. Happy together: A structural model of couples' joint retirement choices. *Working Paper*, November 2010.

M. De Nardi. Wealth inequality and intergenerational links. *Review of Economic Studies*, 71(3): 743–768, 2004.

M. De Nardi, E. French, and J. B. Jones. Why do the elderly save? the role of medical expenses. *Journal of Political Economy*, 118(1):39–75, February 2010.

M. De Nardi, S. Pashchenko, and P. Porapakkarm. The lifetime costs of bad health. *NBER Working Paper no. 23963*, 2018.

I. Dushi, H. M. Iams, and B. Trenkamp. The importance of social security benefits to the income of the aged population. *Social Security Bulletin*, 77(2), 2017.

G. V. Engelhardt and A. Kumar. Taxes and the labor supply of older americans: Recent evidence from the social security earnings test. *National Tax Journal*, 67(2):443–458, 2014.

A. Erosa, L. Fuster, and G. Kambourov. Labor supply and government programs: A cross-country analysis. *Journal of Monetary Economics*, (1):84–107, 2012.

X. Fan, A. Seshadri, and C. Taber. Estimation of a life-cycle model with human capital, labor supply and retirement. *Working Paper*, 2019.

S. Flood, M. King, R. Rodgers, S. Ruggles, and J. R. Warren. Integrated public use microdata series, 2020. Current Population Survey: Version 8.0 [dataset]. Minneapolis, MN: IPUMS, `https://doi.org/10.18128/D030.V8.0`.

E. French. The effects of health, wealth, and wages on labour supply and retirement behaviour. *Review of Economic Studies*, 72:395–427, 2005.

E. French and J. B. Jones. The effects of health insurance and self-insurance on retirement behavior. *Econometrica*, 79(3):693–732, May 2011.

E. French and J. B. Jones. Public pensions and labor supply over the life cycle. *International Tax and Public Finance*, 19:268–287, 2012.

L. Friedberg. The labor supply effects of the social security earnings test. *The Review of Economics and Statistics*, 82(1):48–63, February 2000.

L. Fuster, A. İmrohoroğlu, and S. İmrohoroğlu. Elimination of social security in a dynastic framework. *Review of Economic Studies*, 74(1):113–145, January 2007.

A. Gelber, D. Jones, D. W. Sacks, and J. Song. The employment effects of the social security earnings test. *Forthcoming, Journal of Human Resources*, 2018.

P. Gourinchas and J. A. Parker. Consumption over the life cycle. *Econometrica*, 70(1):47–89, January 2002.

M. Groneck and J. Wallenius. It sucks to be single! marital status and redistribution of social security. *SSE Working Paper Series in Economics No. 2017:1*, 2017.

N. Guner, R. Kaygusuz, and G. Ventura. Taxation and household labour supply. *The Review of Economic Studies*, 79(3):1113–1149, July 2012.

P. Haan and V. Prowse. Longevity, life-cycle behavior and pension reform. *Journal of Econometrics*, 178:582–601, 2014.

J. J. Heckman. The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. In S. V. Berg, editor, *Annals of Economic and Social Measurement*, volume 5, pages 479–492. National Bureau of Economic Research, October 1976.

R. Hosseini, K. A. Kopecky, and K. Zhao. The evolution of health over the life cycle. *Review of Economic Dynamics*, forthcoming.

R. G. Hubbard, J. Skinner, and S. P. Zeldes. Precautionary saving and social insurance. *Journal of Political Economy*, 103(2):360–399, April 1995.

S. Imrohoroğlu and S. Kitao. Social security reforms: Benefit claiming, labor force participation, and long-run sustainability. *AMERICAN ECONOMIC JOURNAL: MACROECONOMICS*, 4(3): 96–127, July 2012.

J. B. Jones and Y. Li. The effects of collecting income taxes on social security benefits. *Journal of Public Economics*, 159:128–145, March 2018.

K. L. Judd. *Numerical Methods in Economics*, volume 1. The MIT Press, 1 edition, September 1998.

M. P. Keane. Life-cycle labour supply with human capital: Econometric and behavioural implications. *The Economic Journal*, 126(592):546–577, May 2016.

M. P. Keane and S. Imai. Intertemporal labor supply and human capital accumulation. *International Economic Review*, 45(2):601–641, May 2004.

M. P. Keane and N. Wasi. Labour supply: The roles of human capital and the extensive margin get access arrow. *The Economic Journal*, 126(592):578–617, May 2016.

K. A. Kopecky and T. Koreshkova. The impact of medical and nursing home expenses on savings. *American Economic Journal: Macroeconomics*, 6:29–72, 2014.

T. Laun and J. Wallenius. Social insurance and retirement: A cross-country perspective. *Review of Economic Dynamics*, 22:72–92, October 2016.

Y. Li. Paradoxical effects of increasing the normal retirement age: A prospective evaluation. *European Economic Review*, 101:512–527, January 2018.

H. Low. Self-insurance in a life-cycle model of labour supply and savings. *Review of Economic Dynamics*, 8(4):945–975, 2005.

H. Low and L. Pistaferri. Disability insurance and the dynamics of the incentive insurance trade-off. *American Economic Review*, 105(10):2986–3029, 2015.

N. Maestas and J. Zissimopoulos. How longer work lives ease the crunch of population aging. *Journal of Economic Perspectives*, 24(1):139–160, Winter 2010.

A. Michaud and D. Wiczer. The disability option: Labor market dynamics with economic and health risks. *Working Paper*, 2019.

S. Park. A structural explanation of recent changes in life-cycle labor supply and fertility behavior of married women in the united states. *European Economic Review*, 102:129–168, 2018.

S. Pashchenko and P. Porapakkarm. Reducing medical spending of the publicly insured: The case for a cash-out option. *AMERICAN ECONOMIC JOURNAL: ECONOMIC POLICY*, 11(3): 390–426, AUGUST 2019.

R. Rogerson and J. Wallenius. Fixed costs, retirement and the elasticity of labor supply. *Journal of Economic Theory*, 144(6):2277–2292, November 2009.

R. Rogerson and J. Wallenius. Secular changes in employment of older individuals. *NBER Macroeconomics Annual*, 36, 2021.

J. Rust and C. Phelan. How social security and medicare affect retirement behavior in a world of incomplete markets. *Econometrica*, 65(4):781–831, July 1997.

T. Schirle. Why have the labor force participation rates of older men increased since the mid-1990s? *Journal of Labor Economics*, 26(4):549–594, October 2008.

Social Security Administration. The 2019 annual report of the board of trustees of the federal old-age and survivors insurance and federal disability insurance trust funds. Technical report, 2019.

Social Security Administration. The 2020 annual report of the board of trustees of the federal old-age and survivors insurance and federal disability insurance trust funds. Technical report, 2020.

Social Security Administration. Understanding the benefits. Technical report, 2021.

Appendix A. DATA Appendix

The bulk of my model estimation is based on the 1968 to 2015 waves of the Panel Study of Income Dynamics (PSID). I also use data from the Medical Expenditure Panel Survey (MEPS) for medical spending analysis. This section provides information for these data sets.

A.1. Panel Study of Income Dynamics (PSID)

The PSID is a longitudinal study of a representative sample of the U.S. population. It provides high-quality information on, among other things, labor market behaviors, income, health status, and wealth. In 1968, about 4,800 families were first interviewed, with information gathered on these families and their descendants from that time onwards. Individuals are followed and interviewed annually (biennially since 1997) to maintain a representative sample of families. The PSID sample includes all persons living in the PSID families in 1968 plus anyone subsequently born to or adopted by a sample person.

The original 1968 PSID sample consists of 1,872 low-income families from the Survey of Economic Opportunity (SEO) and a nationally representative sample of 2,930 families designed by the Survey Research Center (SRC) at the University of Michigan. I select all individuals in the SRC sample who are interviewed in the waves 1968-2015. Since the PSID has stopped following most families from the SEO sample after 1997 and to make data more representative to the U.S. population, I drop the SEO sample. Further, I keep male household heads and their spouses, if present, and individuals age between 20 and 90. I pick male household heads born in 1920-1935 as the 1930s cohort and male heads born in 1945-1960 as the 1950s cohort.

Table A.1: PSID Sample Selection

Selection	Individuals	Observations
Initial sample	76,880	3,075,200
Non-SEO sample	36,430	1,457,200
Household heads and spouse if present	21,225	265,743
Male household heads	10,472	123,650
Age 20 to 90	10,407	122,730
The 1930s cohort	984	20,091
The 1950s cohort	2,844	45,945

Table A.1 reports the sample selection and sample size. The resulting sample includes 984 individuals and 20,091 observations for the 1930s cohort. I use data from the PSID to estimate the health status transition, wage process, survival probabilities, wife's earnings, initial distribution over state variables, and the moment conditions that my model is estimated to match.

A.2. Medical Expenditure Panel Survey (MEPS)

The MEPS is a nationally representative survey of families, individuals, their medical providers and employers across the United States. It contains individuals of all ages but age is top coded at age 85. The medical spending reported in the MEPS is at the individual level and cross-checked with medical providers and insurance companies, which improves the accuracy of the data. I use data from the 1999-2012 waves of MEPS, drop observations with missing values of age, medical spending, health insurance information during the working periods, or health status, and keep household head above age 20 only. The resulting sample comprises 120,731 persons and 211,709 person-year observations.

I use data from the MEPS to estimate the life-cycle profiles of out-of-pocket medical expenses by health status for a representative population.

Table A.2: MEPS Sample Selection

Selection	Individuals	Observations
Initial sample	259,263	491,795
Household heads	130,978	231,866
Age above 20	125,587	222,495
With insurance information at 25-65	121,385	213,005
Non-missing health status	120,731	211,709

Appendix B. Labor Supply Trends By Demographic Groups

This section provides empirical facts on labor supply trends and compositional changes in demographic groups across the 1930s and 1950s cohorts. Using the data from the PSID, I document the compositional changes in education and occupation across cohorts, but the increases in the labor supply at older ages do not differ across either educational or occupational groups.

B.1. **Education**

Men born in the 1950s have a higher share with a college degree than the 1930s cohort over the lifetime. Figure B.1 shows the shares of people with a college degree over ages 30 to 70 between the 1930s and 1950s cohorts. From it, we can see that there is a more than 15 percentage point higher share of people with a college degree at older ages.

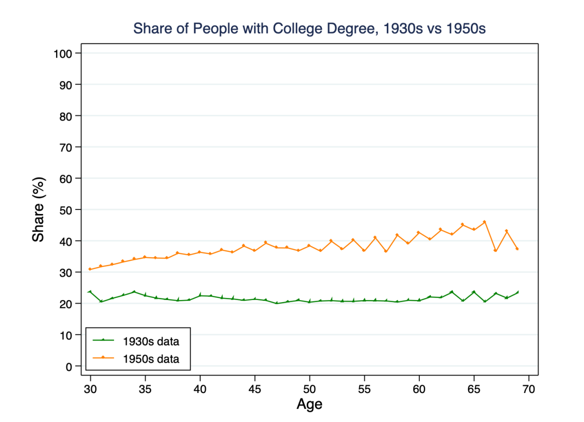
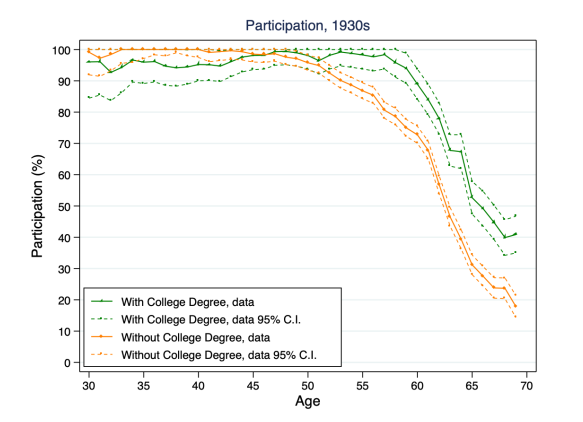


Fig. B.1. Shares of People with College Degree, 1930s vs 1950s

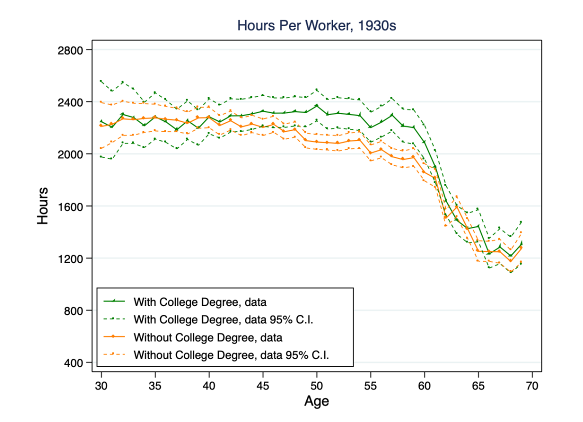
Notes: Shares of people with college degree over ages 30-70, comparing the 1930s cohort (green) and the 1950s cohort (orange) for American men.
Data Source: Panel Study of Income Dynamics, author's calculations.

Figure B.2 (panel a and panel b) displays the life-cycle profiles of labor force participation and hours worked per worker of the 1930s cohort by educational groups (green: with a college degree; orange: without a college degree). The effect of college educational attainment on hours worked per worker at older ages is not statistically significant, but its impact on the labor force participation is large after age 50. For example, the participation rate of people with a college degree at age 65 is over 20 percentage points higher than that of people without a college degree.

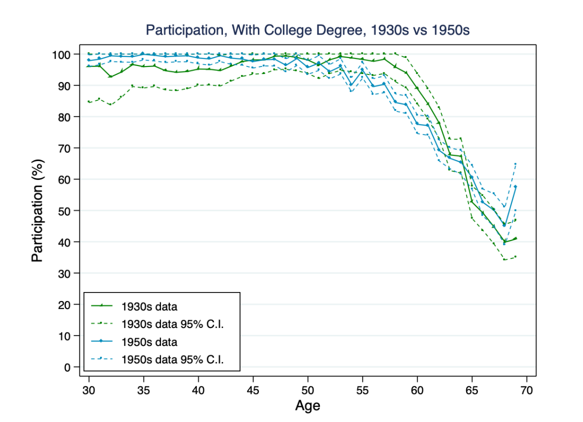
Comparing the labor supply behaviors across the 1930s and the 1950s cohorts by educational groups, as shown in Figure B.2 (panels c-f), the 1950s cohort has higher participation rates and hours per worker at older ages than the 1930s cohort, but those increased older-age labor behaviors do not differ across educational groups.



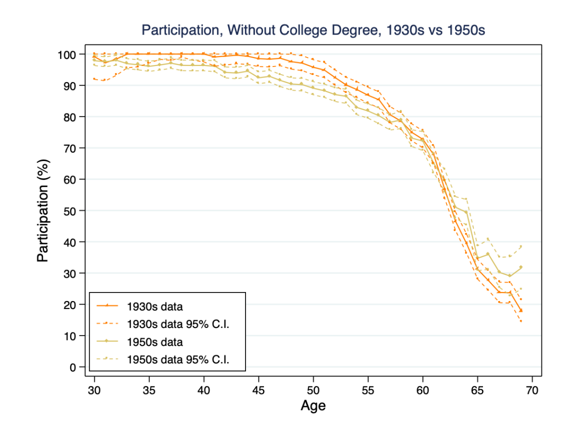
(a) Labor Force Participation



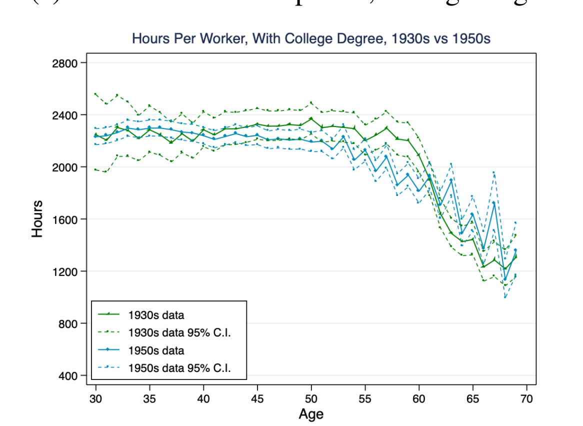
(b) Hours Worked by Workers



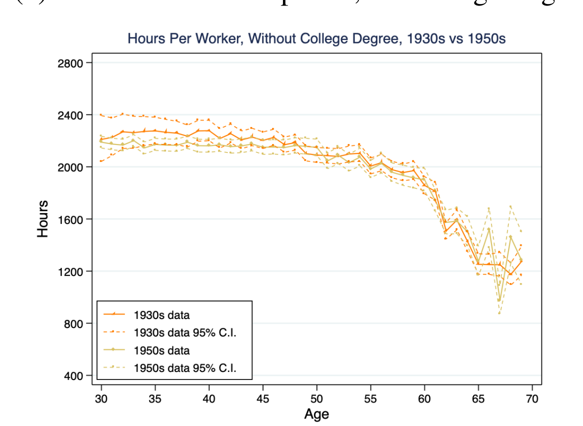
(c) Labor Force Participation, College Degree



(d) Labor Force Participation, No College Degree



(e) Hours Worked by Workers, College Degree



(f) Hours Worked by Workers, No College Degree

Fig. B.2. Labor Supply Across Cohorts and Educational Groups

Notes: Panel a and panel b display the life-cycle profiles of labor participation and hours worked by workers in the 1930s cohort, comparing educational groups: with a college degree (green) and without a college degree (orange) for American men. Panel c and panel d display the data profiles of life-cycle labor participation across cohorts, comparing men with and without a college degree. Panel e and panel f display the data profiles of life-cycle hours worked by workers across cohorts and educational groups. Green and orange indicate the profiles of the 1930s cohort, while blue and gold indicate those of the 1950s cohorts. The 95% confidence intervals are represented by dotted lines.

Data Source: Panel Study of Income Dynamics, author's calculations.

B.2. **Occupation**

The PSID data sets have eight occupation categories, as shown in Table B.1. Using the data from the PSID, I document the compositional changes in occupation over age ranges 30-70 and over older ages 60-70 across cohorts. There are several patterns worth noticing. Over ages 30-70, the composition of those eight occupational categories does not show significant changes between the 1930s and 1950s cohorts. However, comparing the composition at older ages 60-70 only, there are some changes in employment sectors. For instance, the 1950s cohort has higher shares of people in the occupation groups of "Professional, technical and kindred workers" and "Self-employed businessmen" at older ages; and fewer people in the groups of "Clerical and sales workers" and "Craftsmen, foremen, and kindred workers" than the 1930s cohort.

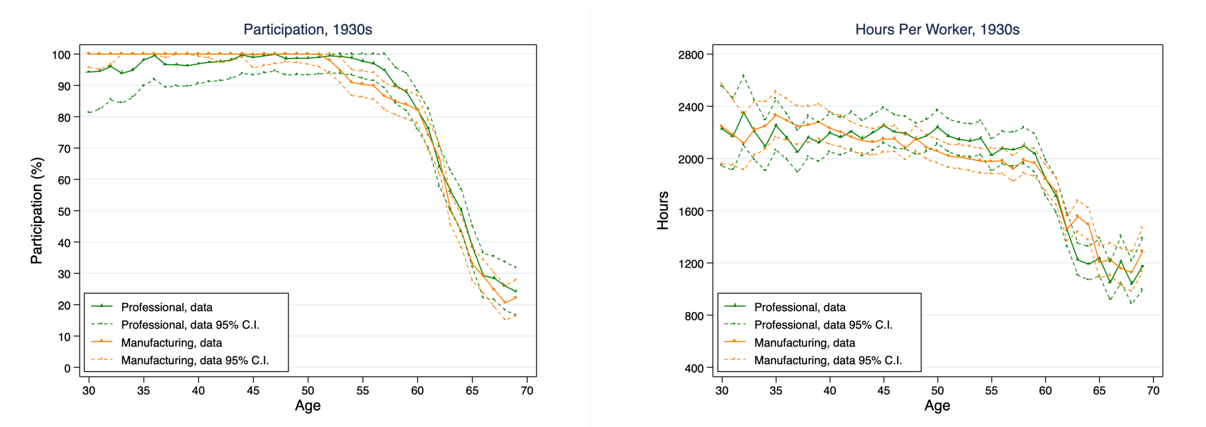
Table B.1: Compositional Changes in Occupation

Occupation Category	Ages 60-70 1930s (%)	Ages 60-70 1950s (%)	Ages 30-70 1930s (%)	Ages 30-70 1950s (%)
1. Professional, technical and kindred workers	17.82	20.57	17.30	17.01
2. Managers, officials and proprietors	17.84	17.08	16.32	15.75
3. Self-employed businessmen	18.73	19.94	18.39	18.58
4. Clerical and sales workers	10.40	9.31	8.66	10.12
5. Craftsmen, foremen, and kindred workers	20.42	17.94	21.33	21.68
6. Operatives and kindred workers	10.76	10.81	13.40	12.87
7. Laborers and service workers, farm laborers	3.92	4.36	4.33	3.86
8. Farmers and farm managers	0.10	0.00	0.28	0.13

Source: Panel Study of Income Dynamics, author’scalculations.

As it is difficult to use the main categories to identify which people are working in manufacturing at older ages, e.g., "Self-employed businessmen," I only choose the types that are representative of manufacturing jobs and professional jobs. I define men in manufacturing if they belong to "Clerical and sales workers" and "Craftsmen, foremen, and kindred workers" and those in professional if they belong to "Professional, technical and kindred worker."

Figure B.3 (panels a and b) displays the life-cycle profiles of labor force participation and hours worked per worker of the 1930s cohort by occupational groups (green: professional; orange: manufacturing). We can see that the effects of employment sectors on the labor participation and hours per worker at older ages are not statistically significant.



(a) Labor Force Participation

(b) Hours Worked by Workers

Fig. B.3. Labor Supply Across Occupation Groups, 1930s

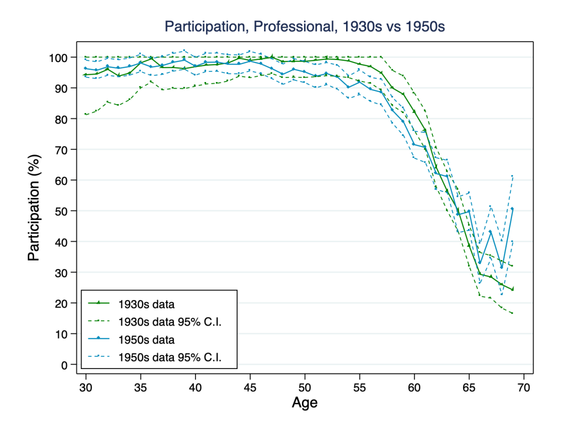
Notes: Data profiles of life-cycle labor participation (panel a) and hours worked by workers (panel b), comparing occupational groups: the professional (green) and the manufacturing (orange) for American men, the 1930s cohort. The 95% confidence intervals are represented by dotted lines.

Data Source: Panel Study of Income Dynamics, author's calculations.

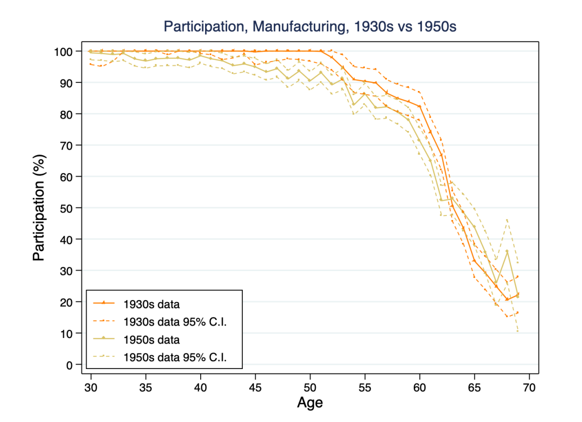
Comparing the labor supply behaviors between the 1930s and the 1950s cohorts, as shown in Figure B.4 (panels a-d), the 1950s cohort has higher participation rates and hours per worker at older ages than the 1930s cohort. Similar to the labor supply patterns by educational groups, those increased older-age labor behaviors do not differ across professional and manufacturing sectors.

In summary, there are distinct changes in compositions of education and occupation across cohorts. However, using the data from the PSID, I find that the increases in the labor supply behaviors at older ages do not present significant differences across those demographic groups. Unlike shown in Section 2 that the increase in the labor supply of American men at older ages is mainly driven by men in good health, this appendix section documents that the older-age labor supply is higher in the younger cohort regardless of education and occupation.

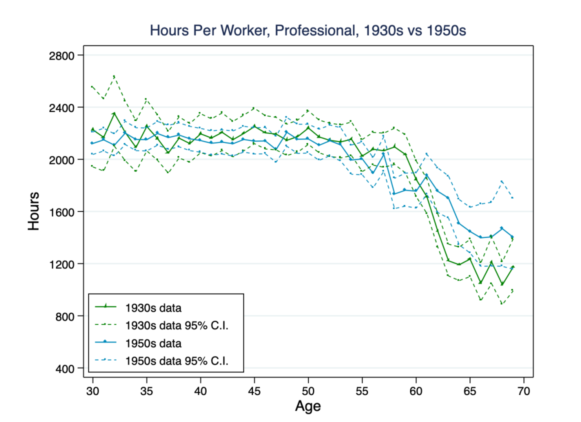
Moreover, using data from the CPS and the HRS, a recent paper, Cajner et al. (2021), documents that the increase in the labor force participation of American men at older ages is mainly driven by men in good health and does not differ across either educational or occupational groups, which provides additional evidence to my empirical facts.



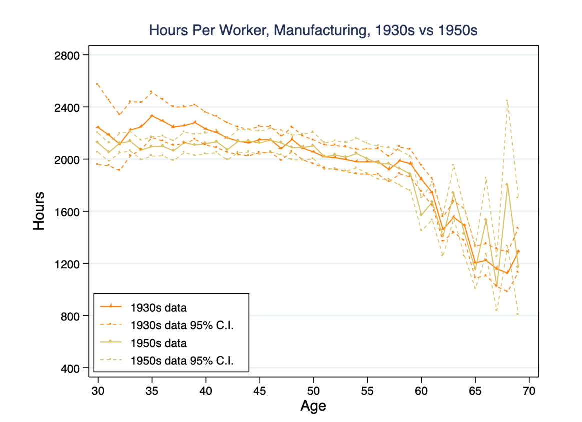
(a) Labor Force Participation, Professional



(b) Labor Force Participation, Manufacturing



(c) Hours Worked by Workers, Professional



(d) Hours Worked by Workers, Manufacturing

Fig. B.4. Labor Supply Across Cohorts

Notes: Data profiles of life-cycle labor participation in the occupation groups: professional (panel a) and manufacturing (panel b), and profiles of life-cycle hours worked by workers in the occupation groups: professional (panel c) and manufacturing (panel d), comparing the 1930s and the 1950s cohorts for American men. The 95% confidence intervals are represented by dotted lines.

Data Source: Panel Study of Income Dynamics, author's calculations.

Appendix C. Target Profiles

The target profiles of labor force participation, hours worked by workers, and savings for healthy and unhealthy people in the 1930s cohort are constructed using the data from the PSID and by running the fixed-effects regression equation (21). I mainly follow the procedure adopted in French (2005).

Labor force participation is a dummy variable and counted as one if the individual's annual hours worked are more than 300 hours per year. Hours worked are measure with self-reported working hours from the survey. Respondents in survey year t report their total hours of work in year $t-1$. Hours are counted as zero if the reported annual hours worked are below 300 hours.

The measurement of assets includes real estate, the value of a farm or business, vehicles, stocks, mutual funds, IRAs, Keoghs, liquid assets, bonds, and investment trusts, net of mortgages and other debts. It does not include pension or Social Security wealth. I define assets as the sum of all above asset types, plus the value of home equity, and net of debts. I exclude the extremely wealthy or poor observations in the top 5% and bottom 1% of the sample. Assets in the PSID have only been observed in 1984, 1989, 1994, 1999, 2001, 2003, 2005, 2007 PSID wealth surveys, and 2009, 2011, 2013, 2015 PSID family files.

To impute the assets in the missing years, I run the fixed-effect regression for assets on a set of variables, including age polynomials, its interaction with health status, and with log wages, family size, education, unemployment rates, a dummy for health status, its interaction with unemployment rates, and with log wages (e.g., Borella et al. (2019b)). I then use the imputed and the actual observations to estimate the assets profiles by health status that are used as target moments and to compute the initial joint distribution.

Appendix D. Numerical Methods

The decision rules are solved numerically using value function iteration, starting at the period T and working backward to the first period. Recall that decision rules solve:

$$\begin{aligned}
V_t(X_t) &= \max_{c_t,n_t,b_t} \{u(c_t,l_t) + \beta s_{t+1} E_t[V_{t+1}(X_{t+1})] + \beta(1-s_{t+1})b(a_t)\} \\
&= \max_{c_t,n_t,b_t} \{\frac{1}{1-\nu}(\ c_t^{\gamma}\ [L_t - n_t - \theta_p^{h_t} p_t - \phi \mathbb{1}_{\{h_t \neq 0\}}]_t^{1-\gamma}\ )^{1-\nu} \\
&\quad + \beta s_{t+1} \int V_{t+1}(X_{t+1}) dF(X_{t+1}|X_t, t, c_t, n_t, b_t) \\
&\quad + \beta(1-s_{t+1}) b(a_{t+1})\}
\end{aligned}$$

At time T, consumption decision c_T is made by solving the above problem $V_T(X_T)$ with the terminal value $V_{T+1} = B(a_{T+1})$. Given the decision rules and value function at time T, I then solve decision rules at time $T-1$, $T-2$, ..., 0, using backward induction.

I discretize the state variables χ into a finite number of points within a grid. I directly compute the value function at these points and integrate the value function with respect to the innovation of wages using five-node Gauss-Hermite quadrature (see Judd (1998)). Also, I use linear interpolation within the grid and linear extrapolation outside of the grid to evaluate value function at points that can not be directly computed.

The grid consists of 30 asset states, $a_j \in [\$0, \$660000]$; 10 wage states, $w_j \in [\$3, \$60]$; 10 AIME states, AIME$_j \in [\$2000, \$43800]$ (in 1987 dollars); 2 Social Security application states; and 3 health states (good health, bad health, disabled state). In particular, I solve the value function at 9,000 different points at the first stage; 18,000 points at the second stage; and 900 points at the third stage. Following French (2005), since changes in assets, wages, and AIME are intended to cause larger behavioral responses at low levels of these state variables, the grid is more finely discretized at these levels. In addition, I discretize the the consumption and hours worked decision space and find the optimal decisions by searching over the grid. There are 180 points for consumption, and the hours worked grid is broken into 300-hour intervals.

I then use the decision rules to generate simulated life-cycle histories of individuals using forward induction. For instance, given the realized state variables X_0, I can find an individual's decision at time 0 using the decision rules at $t = 0$. Then given time-0 decisions, the state variables X_1 can be obtained using χ_0 and shocks at time 1, the same for $t = 2, ...T$.

Appendix E. Method of Simulated Moments

I proceed with the MSM in the following steps. First, I estimate the life-cycle profiles for labor force participation, hours worked, and assets by health status from the data. Second, I estimate the initial distribution for relevant state variables and a set of parameters that determine the data generating process for the state variables, χ, as in the first step. Then taking as given χ, generate matrices of health and wage shocks. Third, I iterate on the following procedure for different values of Θ until the minimum distance, as in Equation (20), has been found.

1. Given Θ, solve the model and generate the simulated life-cycle profiles for decision variables.
2. Compute moment conditions and calculate the distance between the simulated profiles and data profiles described in Equation (20).
3. Pick a new vector of preference parameters, Θ_{new}, and repeat the above two steps.

Appendix F. Additional Tables

Table F.1: Estimated Coefficients for the Survival Probabilities

	Coefficients	S.E.
Age^2	-0.0006***	(0.0000)
Health_{t-1}	-1.0586***	(0.1202)
Cohort	1.2168***	(0.3214)
Cohort$\times$$\text{Age}^2$	-0.0002***	(0.0001)
Cohort$\times$$\text{Health}_{t-1}$	-0.6850***	(0.2081)
Constant	6.9298***	(0.2051)
Observations	57,549	

[1] Notes: Estimated Coefficients of Logistic Regression. Dependent Variable: Indicator of survival. Robust Standard Errors in parentheses, clustered at the individual level. $*p < 0.10, **p < 0.05, ***p < 0.01$.

[2] Source: Panel Study of Income Dynamics, author's calculations.

Table F.2: Estimated Coefficients for the Logarithm of Hourly Wages

	Coefficients	S.E.
	Wage Equation	
Age	0.0688***	(0.0164)
Age^2	-0.0007***	(0.0002)
Health$\times$Age	-0.0101***	(0.0022)
Health$\times$$\text{Age}^2$	0.0001***	(0.0000)
Constant	1.2145***	(0.3808)
	Selection Equation	
Age	-0.0034	(0.0182)
Age^2	-0.0009***	(0.0001)
Health	0.3449***	(0.0633)
Health$\times$Age	-0.0567***	(0.0025)
Health$\times$$\text{Age}^2$	0.0007***	(0.0000)
Family Size	0.0115	(0.0094)
Birth Year	-0.0135***	(0.0031)
Constant	30.1581***	(6.0534)
Inverse Mill's Ratio	0.0494	(0.0984)
Observations	16,438	

[1] Notes: Estimated Coefficients of Two-Stage Heckman Selection Model. Dependent variable of wage equation: logarithm of the wages. Dependent variable of selection equation: indicator of labor force participation. Robust Standard Errors in parentheses, clustered at the individual level. $*p < 0.10, **p < 0.05, ***p < 0.01$.

[2] Source: Panel Study of Income Dynamics, author's calculations.

Table F.3: Estimated Coefficients for the Spousal Earnings

	Coefficients	S.E.
Age	1027.5790***	(78.8423)
Age^2	-8.0476***	(0.7428)
$Health$	2774.508*	(1421.4030)
$Health \times Age$	-57.0864**	(24.6183)
$Wages$	15.8867	(10.7239)
$Constant$	-24567.8700***	(2046.0310)
Observations	12,947	

[1] Notes: Dependent Variable: Wife's annual earnings. Robust Standard Errors in parentheses, clustered at the individual level. $*p < 0.10, **p < 0.05, ***p < 0.01$.
[2] Source: Panel Study of Income Dynamics, author's calculations.

Table F.4: Summary Statistics for the Initial Conditions

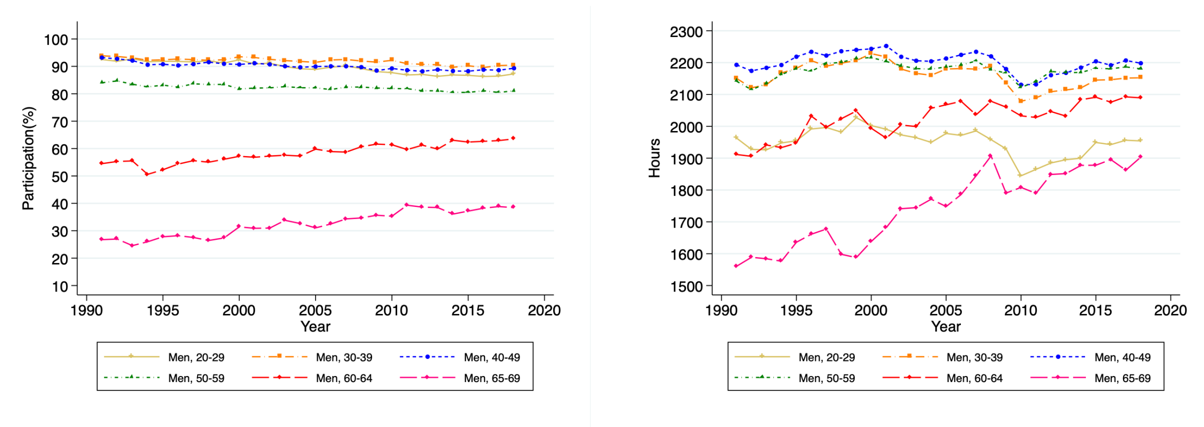
		Health Status		
	Overall	Good	Bad	Disabled
Assets (in 2016 dollars)				
Mean	42,164	42,611	36,020	13,507
Standard Deviation	56,935	57,457	46,480	15,600
Wages (in 2016 dollars)				
Mean	18.91	19.09	15.60	12.91
Standard Deviation	10.32	10.38	8.40	7.67
Percentage		95.28	4.11	0.61
Observations	2,479	2,362	102	15

Source: Panel Study of Income Dynamics, author's calculations.

Table F.5: Labor Supply Elasticity to a 20% Wage Increase

	Temporary Wage Increase			Permanent Wage Increase		
	Age 40	Age 50	Age 60	Age 40	Age 50	Age 60
In the year of wage change	0.43	0.61	1.16	0.27	0.47	1.08
Healthy	0.43	0.53	1.01	0.26	0.40	0.93
Unhealthy	0.51	1.21	1.89	0.34	0.99	1.84
After the year of wage change	-0.02	-0.01	0.14	0.26	0.63	1.80
Healthy	-0.01	-0.01	0.12	0.24	0.55	1.66
Unhealthy	-0.03	0.01	0.25	0.39	1.11	2.44

Appendix G. Supplemental Figures



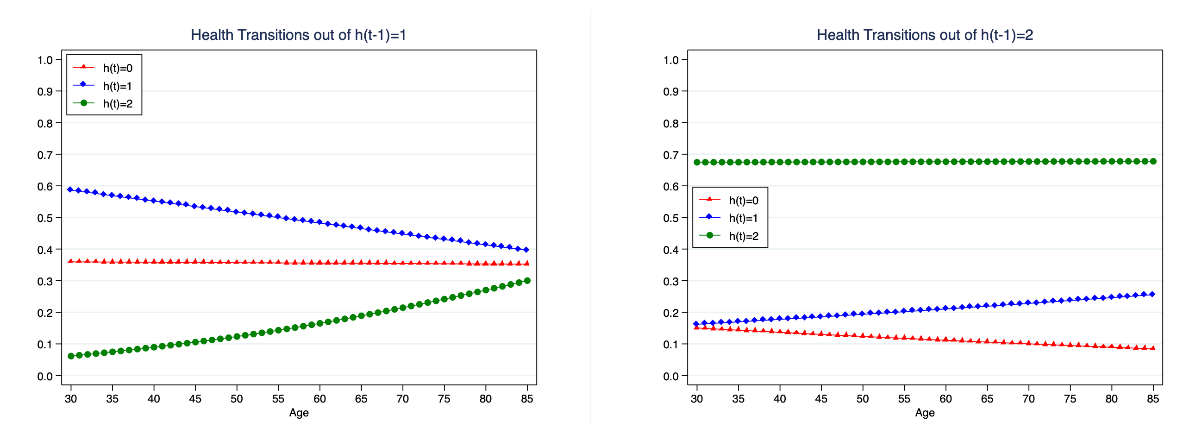
(a) Labor force participation trends

(b) Hours worked trends

Fig. G.1. Labor Supply Trends of Men by Age Groups

Notes: Panel a shows the trends in labor force participation by age groups. Panel b shows the trends in hours worked conditional on participation by age groups.

Source: March Current Population Survey (through IPUMS, see Flood et al. (2020)), author's calculations.



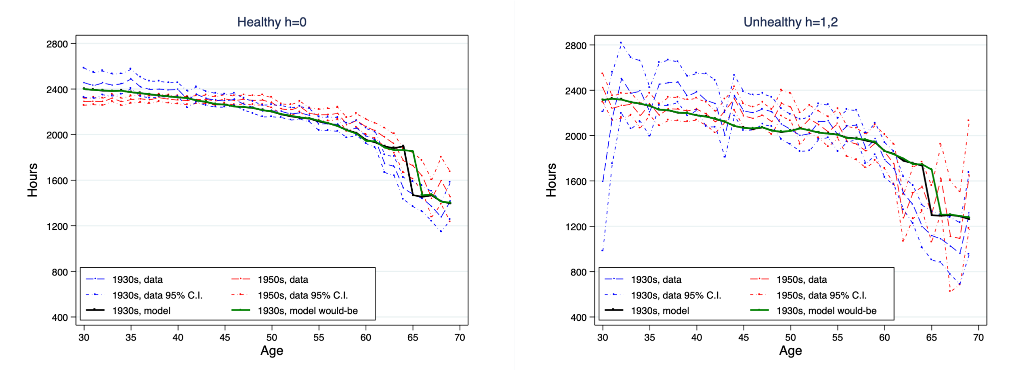
(a) Health transition out of bad health

(b) Health transition out of disabled state

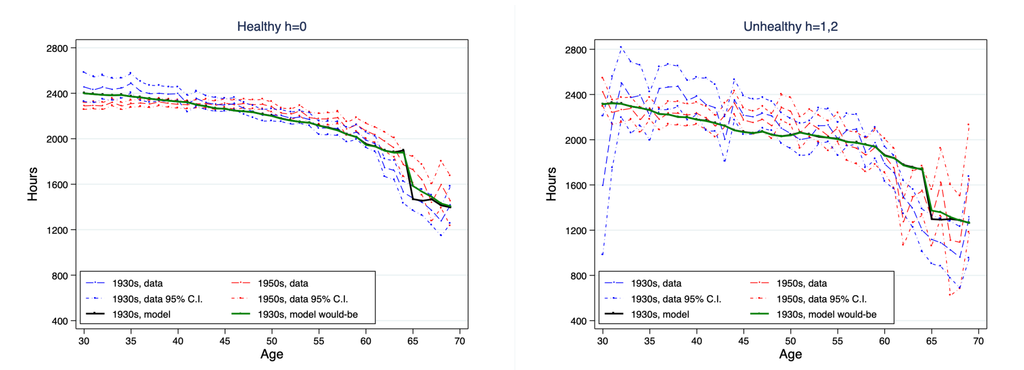
Fig. G.2. Remaining Health Transitions

Notes: Panel a shows the probabilities of transitioning out of bad health. Panel b shows the probabilities of transitioning out of disability status. The red line shows the transition probabilities to good health. The blue line shows the transition probabilities to bad health. The green line shows the transition probabilities to disability status.

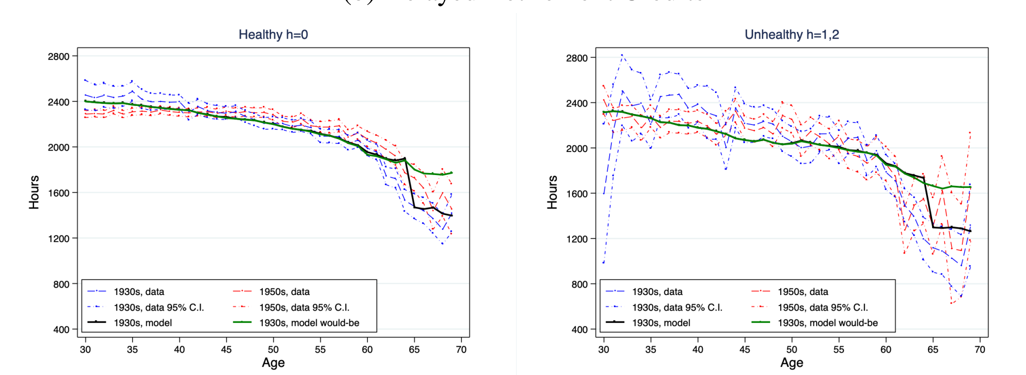
Source: Panel Study of Income Dynamics, author's calculations.



(a) Normal Retirement Age



(b) Delayed Retirement Credits



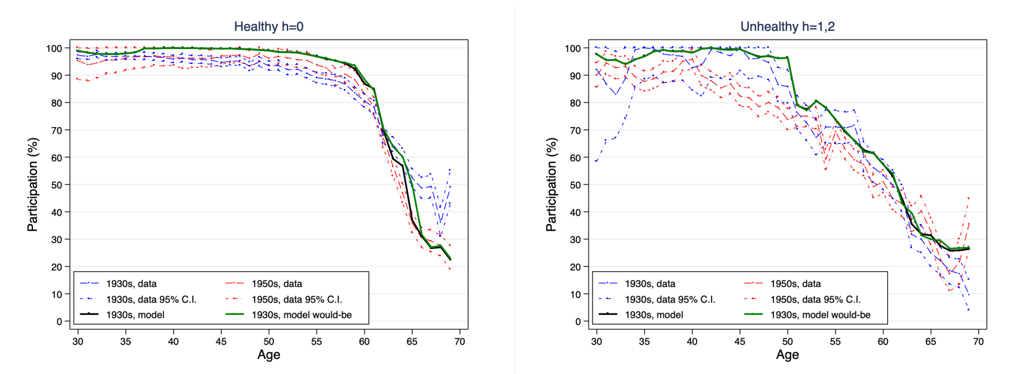
(c) Retirement Earnings Test

Fig. G.3. Model v.s. Data Profiles: Effects of Changing Social Security Rules on Hours Worked by Health Status

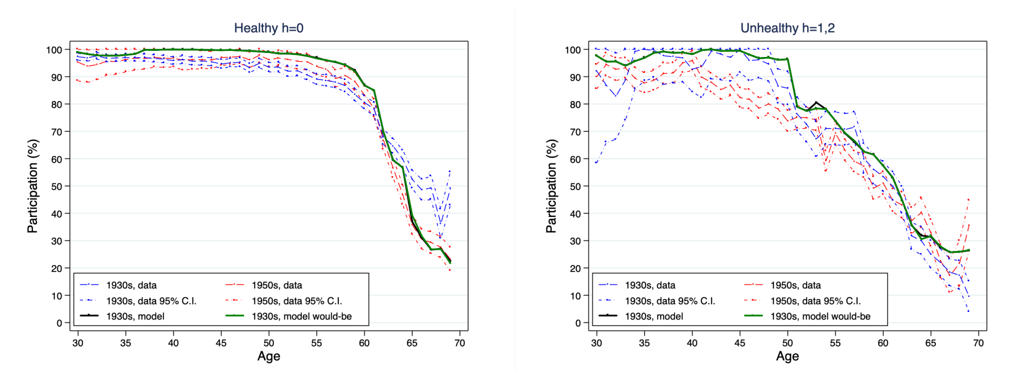
Notes: Effects of the corresponding policy changes on hours worked for healthy workers (left panels) and unhealthy workers (right panels). The black (green) lines represent the model-simulated profiles for the 1930s cohort before (after) implementing policy changes. The blue (red) dashed lines represent the data profiles with 95% confidence intervals for the 1930s (1950s) cohort.

Policy Experiments: increasing the NRA from 65 to 66 (panel a); increasing the DRC from 4.5% to 8% (panel b); removing the RET from 70 to 65 (panel c).

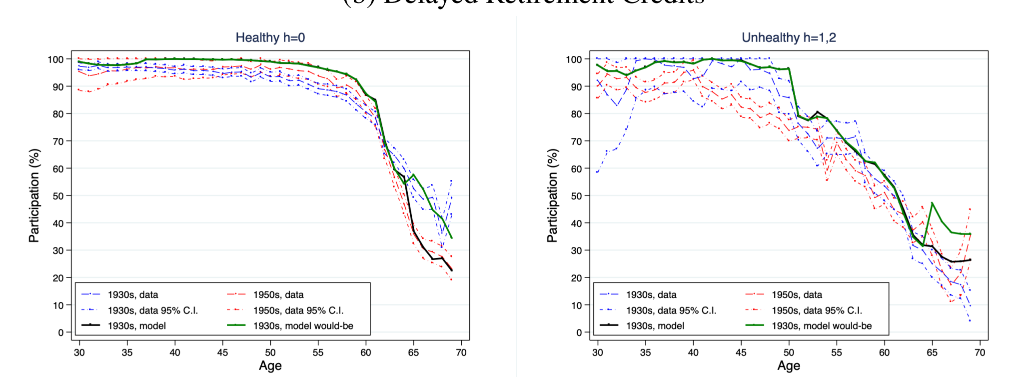
Data Source: Panel Study of Income Dynamics, author's calculations.



(a) Normal Retirement Age



(b) Delayed Retirement Credits



(c) Retirement Earnings Test

Fig. G.4. Model v.s. Data Profiles: Effects of Changing Social Security Rules on Labor Force Participation by Health Status

Notes: Effects of the corresponding policy changes on labor force participation for healthy workers (left panels) and unhealthy workers (right panels). The black (green) lines represent the model-simulated profiles for the 1930s cohort before (after) implementing policy changes. The blue (red) dashed lines represent the data profiles with 95% confidence intervals for the 1930s (1950s) cohort.

Policy Experiments: increasing the NRA from 65 to 66 (panel a); increasing the DRC from 4.5% to 8% (panel b); removing the RET from 70 to 65 (panel c).

Data Source: Panel Study of Income Dynamics, author's calculations.

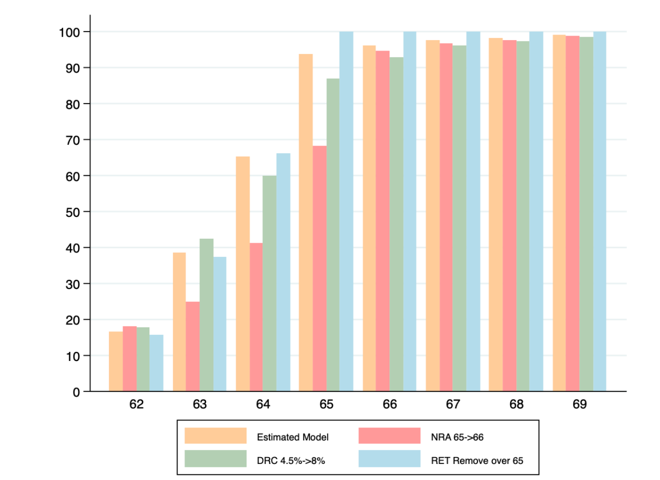
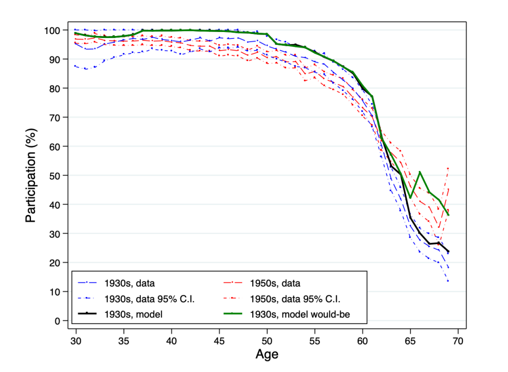
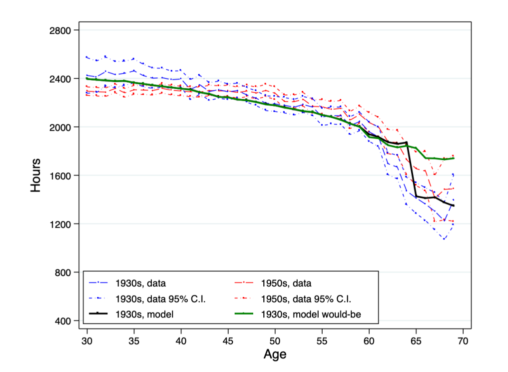


Fig. G.5. Effects of Changing Social Security Rules on Benefit Claiming

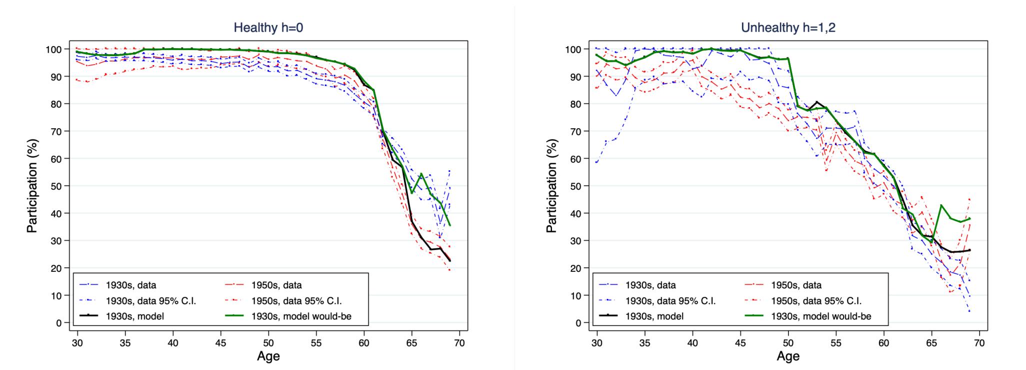
Notes: This figure illustrates model-predicted fraction of individuals who had applied for Social Security retirement benefits at ages 62-69. The orange bar refers to the percentage under the estimated model for the 1930s cohort. The red bar shows the effects of increasing the NRA from 65 to 66. The green bar shows the effects of increasing the DRC from 4.5% to 8%. The blue bar shows the effects of removing the RET from 70 to 65.



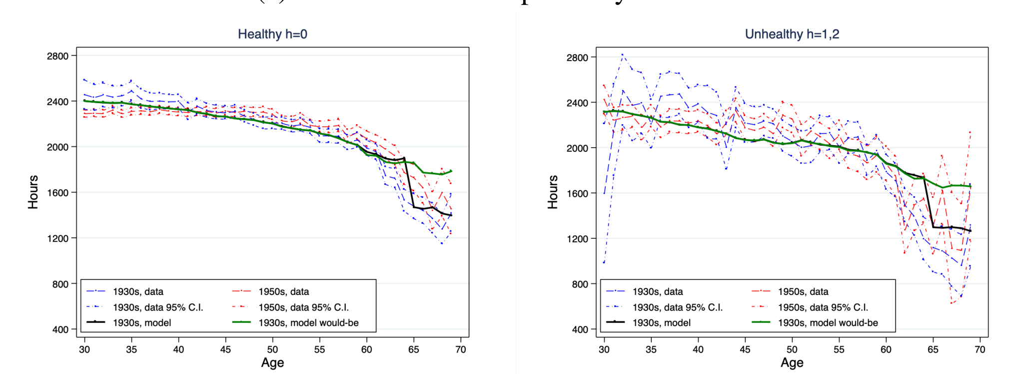
(a) Labor Force Participation



(b) Hours Worked by Workers



(c) Labor Force Participation by Health Status

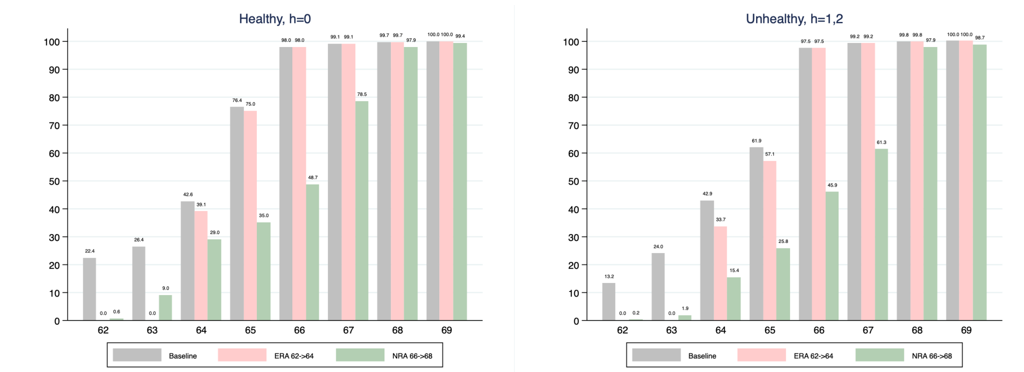


(d) Hours Worked by Health Status

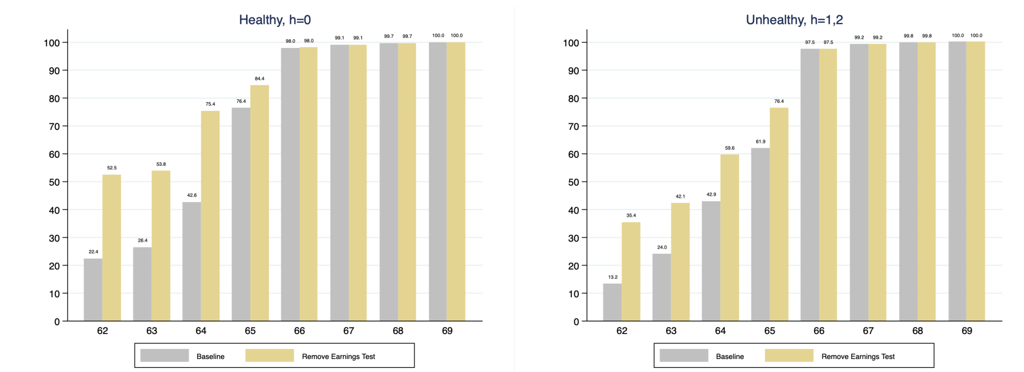
Fig. G.6. Model v.s. Data Profiles: Effects of Changing Three Social Security Rules

Notes: Panel a and panel b show the effects on the labor behaviors at the average level. Panel c and panel d show the effects by health status. The black (green) lines represent the model-simulated profiles for the 1930s cohort before (after) implementing policy changes. The blue (red) dashed lines represent the data profiles with 95% confidence intervals for the 1930s (1950s) cohort.

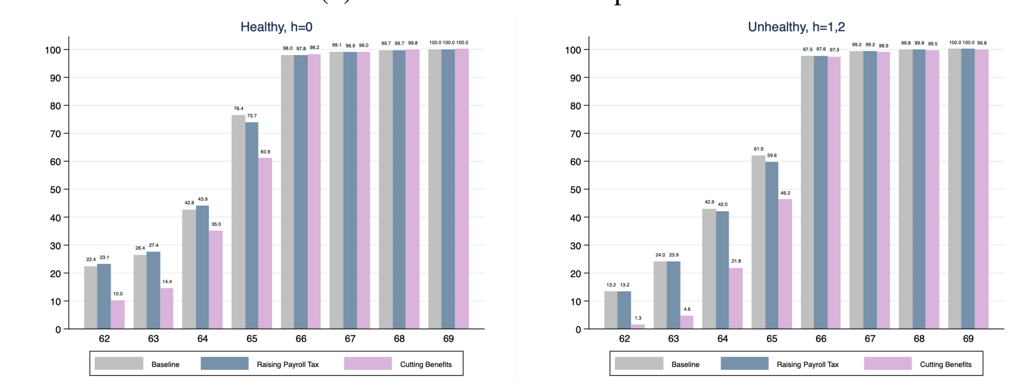
Data Source: Panel Study of Income Dynamics, author's calculations.



(a) The First Set of Experiments



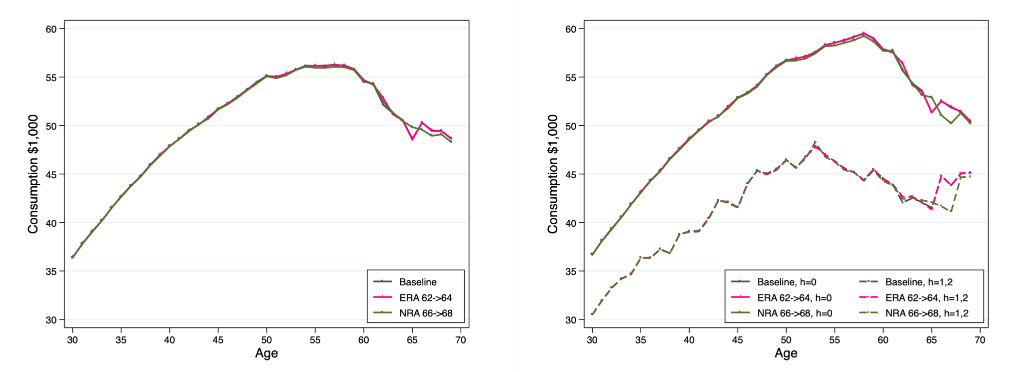
(b) The Second Set of Experiments



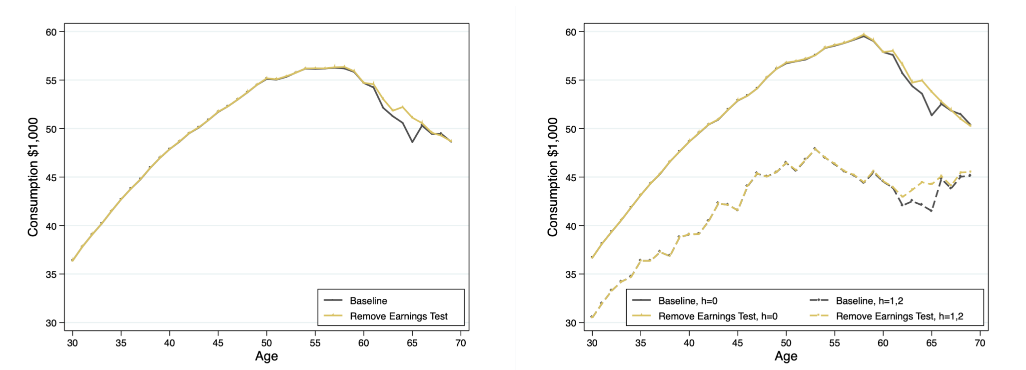
(c) The Third Set of Experiments

Fig. G.7. Policy Experiments on Social Security Application by Health Status

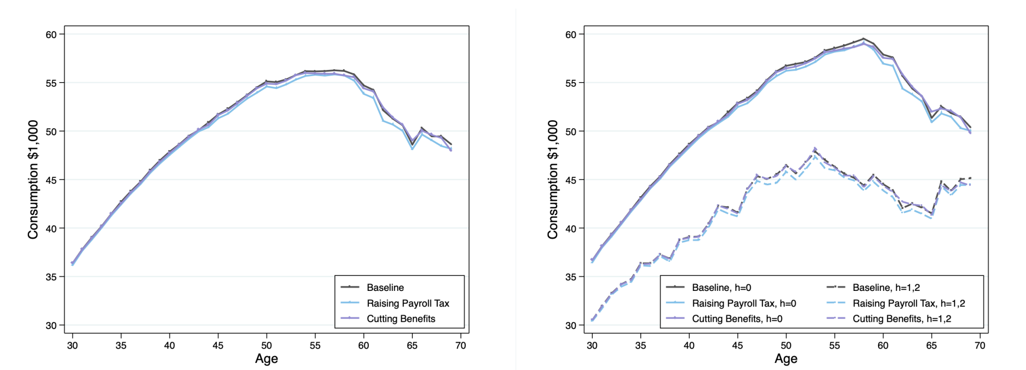
Notes: This figure illustrates model-predicted fraction of healthy individuals (left panels) and unhealthy individuals (right panels) who had applied for Social Security retirement benefits at ages 62-69. The gray "Baseline" bars refer to the percentage under the economy with the Social Security rules faced by the 1950s cohort. Panel a shows the effects of the first set of experiments (increasing the ERA and NRA). Panel b shows the effects of the second set of experiments (removing the RET). Panel c shows the effects of the third set of experiments (increasing the payroll tax and cutting the retirement benefits).



(a) The First Set of Experiments



(b) The Second Set of Experiments



(c) The Third Set of Experiments

Fig. G.8. Policy Experiments on Consumption

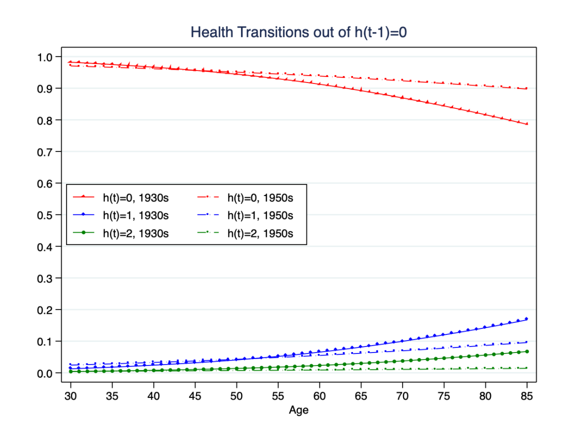
Notes: This figure illustrates model-predicted consumption over the life cycle on average (left panels) and by health status (right panels). The gray "Baseline" lines refer to consumption under the economy with the Social Security rules faced by the 1950s cohort. Panel a shows the effects of the first set of experiments (increasing the ERA and NRA). Panel b shows the effects of the second set of experiments (removing the earnings test). Panel c shows the effects of the third set of experiments (increasing the payroll tax and cutting the retirement benefits).

Appendix H. Effects of Non-Social-Security Changes

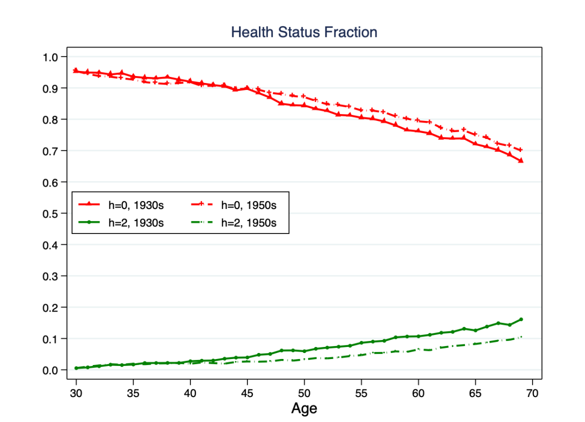
In addition to Social Security rules, health dynamics and income tax rates also vary across cohorts. In this section, I explore the effects of these changes on labor market behaviors.

H.1. Effects of Changing Health Dynamics

Health dynamics change across cohorts. For instance, Figure H.1 (panel a) displays the age-specific health transition out of good health status $Pr(h_t|h_{t-1} = 0)$ for the 1930s cohort (solid lines) and the 1950s cohort (dashed lines). Compared to the older cohort, individuals born in the younger cohort face higher probabilities of staying in good health and lower probabilities of transitioning from good health into bad health or disability status over the life cycle. As a result, relative to the 1930s cohort, the fraction of individuals in good health is higher, whereas that of people with disability is lower in the 1950s cohort, see Figure H.1 (panel b).



(a) Health Transitions Across Cohorts



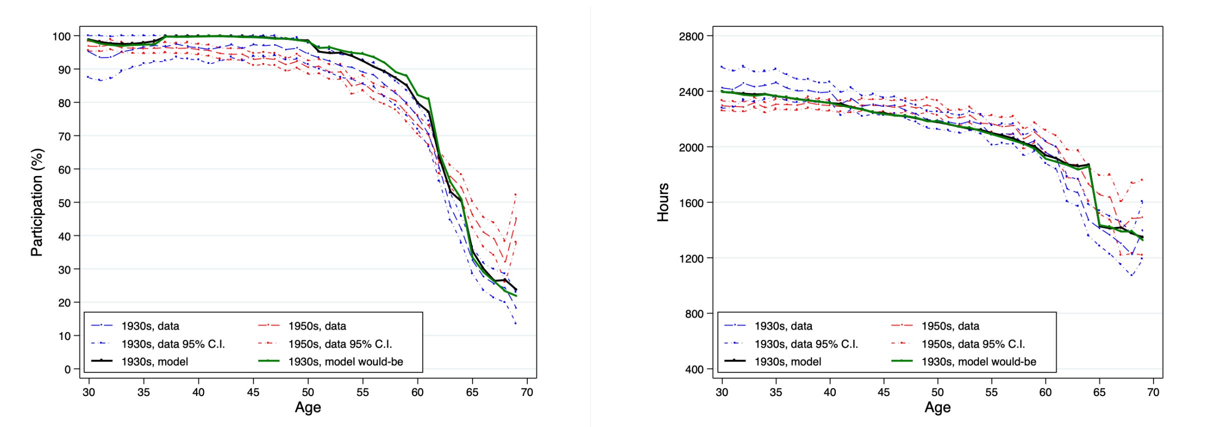
(b) Health Status Fraction Across Cohorts

Fig. H.1. Health Dynamics Across Cohorts

Notes: The solid lines (dashed lines) indicate probabilities/fraction for the 1930s (1950s) cohort. Panel a: The red line shows the transition probabilities from good health to good health. The blue line shows the transition probabilities from good health to bad health. The green lines show the transition probabilities from good health to disabled state. Panel b: The red (green) lines show the fraction of individuals in good health (disabled state).

Source: Panel Study of Income Dynamics, author's calculations.

I then use my estimated model to evaluate the impact of changing health dynamics on the rise of older workers' labor supply across cohorts. Taking the estimated preference parameters from the 1930s model as given, I replace the healthy transition matrix of the 1950s cohort and simulate how the 1930s cohort would behave if they had the same values for those factors as the 1950s cohort. Figure H.2 displays the effects of changing health dynamics on the labor force participation and hours per worker over the life cycle and compares the model-simulated changes with the data profiles across cohorts.



(a) Labor Force Participation

(b) Hours Worked by Workers

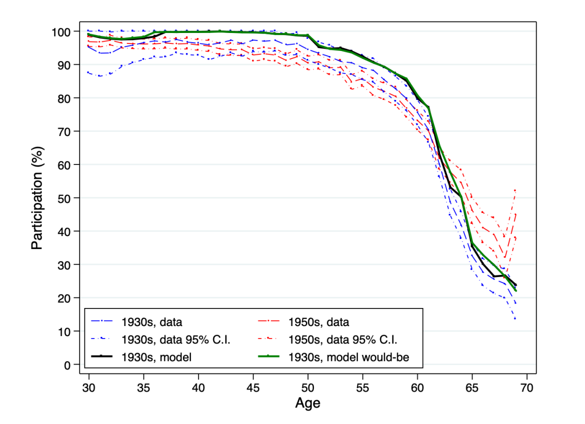
Fig. H.2. Model v.s. Data Profiles: Effects of Changing Health Dynamics

Notes: The effects on the labor behaviors at the average level. The black (green) lines represent the model-simulated profiles for the 1930s cohort before (after) implementing new health dynamics. The blue (red) dashed lines represent the data profiles with 95% confidence intervals for the 1930s (1950s) cohort.
Data Source: Panel Study of Income Dynamics, author's calculations.

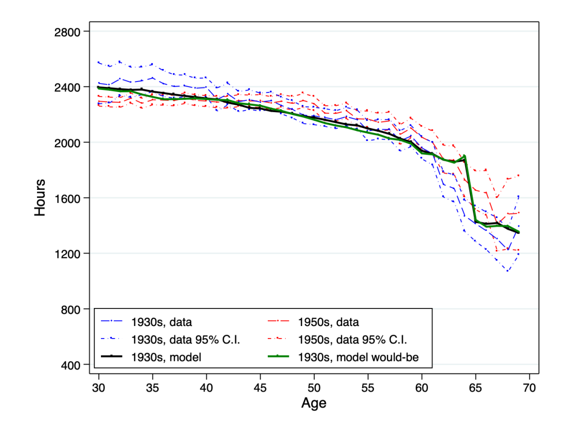
The impact on the labor force participation is small. On average, it only increases the participation rates at ages 60-69 by 0.6% (i.e., by 0.003 percentage points). In addition, changed healthy dynamics have negligible effects on hours worked by workers. It reduces the annual hours worked by 0.7% (i.e., by 11 hours) at ages 60-69.

H.2. **Effects of Changing Marginal Taxes**

As documented in, e.g., Borella et al. (2019a), the progressive income taxes change over years for a specific cohort. Hence, marginal tax rates on income faced by two cohorts at each age change as well. Then taking the estimated preference parameters from the 1930s model as given, I replace the income tax rates of the 1950s cohort, that is estimated following Borella et al. (2019a) and using the data from the PSID, and simulate how the 1930s cohort would behave if they had the same values for those factors as the 1950s cohort. Figure H.3 displays the effects of changing income tax rates on the labor market behaviors along both margins over the life cycle.



(a) Labor Force Participation



(b) Hours Worked by Workers

Fig. H.3. Model v.s. Data Profiles: Effects of Changing Marginal Tax Rates

Notes: The effects on the labor behaviors at the average level. The black (green) lines represent the model-simulated profiles for the 1930s cohort before (after) implementing new marginal tax rates on income. The blue (red) dashed lines represent the data profiles with 95% confidence intervals for the 1930s (1950s) cohort.

Data Source: Panel Study of Income Dynamics, author's calculations.

Similar to the effects of changing health dynamics across cohorts, the impact of changing marginal income tax rates on the labor force participation and hours worked is negligible. Specifically, it only increases the participation rates and annual hours worked at ages 60-69 by 0.01 percentage points and by 0.3 hours, respectively.