Revisiting Retirement and Social Security Claiming Decisions

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Abstract

Why do individuals retire and claim their Social Security benefits at the age they do? Understanding the key drivers of these decisions has been an important topic of research as it can help guide policy discussions on the impact of potential reforms to the Social Security program. We revisit this crucial question by exploring new sources of heterogeneity in these decisions as well as novel mechanisms governing these trade-offs. Using data from the Health and Retirement Study and the Understanding America Survey, we first document (1) important heterogeneities in social security claiming behavior of men by their education and marital status, (2) strong correlations between health, labor supply and benefit claiming decisions and (3) significant misinformation related to Social Security program knowledge and survival chances at older ages. We then build a life-cycle model of consumption, savings, labor supply, and Social Security application decisions as well as heterogeneity in education, marital status and SS program knowledge. The model includes uncertainty in health, subjective survival, wages, and job separation as well as rich details of the U.S. Social Security program to understand why a majority of individuals claim Social Security benefits prior to their normal retirement age, despite large penalties associated with these early benefit claims. We show that the estimated model can closely match the claiming behavior as seen in the data and also produce differences in SS claims along the dimensions of heterogeneity considered. Counterfactual experiments indicate that precautionary motives, misinformation, and preferences governing future discounting as well as altruism, together, go a long way in explaining overall claiming behavior. Together, these forces can explain a third of the overall early benefit claims and two-thirds of age 62 claims– with varying intensities across education and marital groups.

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1 Introduction

It is well known that aging populations put pressure on the pay-as-you-go pension systems. The increasing age of the American workforce requires an urgent discussion of policy reforms geared towards either increasing the tax revenue or decreasing the retirement benefits paid out by the Social Security system in order to balance the budget of the Social Security program. The potential impact of any policy, however, crucially depends on how individuals respond to these changes in terms of their retirement and benefit claiming decisions. This task requires a thorough understanding of the mechanisms behind current decisions, especially if these decisions are at odds with conventional economic theory. Our work focuses on understanding the drivers of early retirement claims. Any claims before the normal retirement age—which ranges between 65 and 67 depending on the birth year—are penalized. For a worker born prior to 1937, claiming Social Security benefits at age 62 gives them a lifetime flow of benefit checks which are 20 percent lower than if they had claimed at age 65. Given this penalty, the pattern of early claims is difficult to rationalize using standard models of retirement and benefit claiming.

In this paper, we document four empirical facts related to early Social Security benefit claims. First, we show that despite the penalties associated with claiming benefits early, many workers choose to claim prior to their normal retirement age.[1] Roughly 50 percent of all working men claim at age 62 and nearly 70 percent have claimed before the normal retirement age. Second, we document a link between labor market participation and the decision to claim benefits. We show that older individuals who are not working in the same year or 1-2 years prior to claiming are more likely to claim benefits early. Third, we show that individuals without a college degree and those in poor health are more likely to claim before their normal retirement age.[2] Finally, we show that many individuals do not understand the penalty associated with early claiming. We estimate that 22 percent of non-college educated workers and 9 percent of college graduates believe there is no penalty for claiming Social Security benefits early. Finally, we show that college educated workers are more likely to underestimate their chances of survival at older ages while those without a college degree overestimate their longevity. We use these empirical facts to inform the mechanisms of the structural model of retirement and Social Security developed in this paper.

Following the literature on structural models of retirement and Social Security claiming[3], we construct a life-cycle model of consumption, savings, labor supply, and Social Security application which includes rich details of the United States Social Security system. Agents are heterogeneous

[1]Previous work has also identified that many household could gain from delaying claims. Coile et al. (2002), Meyer and Reichenstein (2010), Shoven and Slavov (2014a), Shoven and Slavov (2014b), Sun and Webb (2009)

[2]The fact that early claiming is decreasing in education is also documented in Venti and Wise (2014)

[3]Jones and Li (2020) Bairoliya (2019) Pashchenko and Porapakkarm (2018) Borella et al. (2019) De Nardi et al. (2010) Gustman and Steinmeier (2005) Gustman and Steinmeier (2015) Imrohoroglu and Kitao (2012) French and Jones (2011)

with respect to education, marital status, and knowledge of the Social Security program. Additionally, individuals face exogenous shocks to health and survival, labor productivity, and employment status. We separate mechanisms which influence early retirement into four categories: precautionary motives, misinformation motives, bequest motives, and behavioral motives. While some of these channels are identified in other empirical work, we demonstrate that heterogeneous workers are not only impacted differently by these mechanisms but also that these mechanisms interact with one another to produce total early claims. The varying strength of these mechanisms across heterogeneous agents allows us to identify their relative importance.

First, precautionary motives appear in the model through shocks to employment status and health status. Throughout their working lives, workers face a probability of becoming unemployed. Previous studies, such as Chan and Huff Stevens (1999), Chan and Huff Stevens (2001), and Chan and Huff Stevens (2004), have demonstrated that unemployment spells among older workers may drive workers to earlier retirement and claiming. In addition to this channel, unemployment spells throughout a worker's career and the associated wage scarring impacts, lead to lower lifetime earnings and pension benefits. These impacts may push workers to claim benefits early despite penalties. As workers age, they also face increasing risk of falling into poor health. As there are time and productivity costs associated with poor health, workers are induced to retire early rather than delay claims. Each of these risks may also have differential impact on individuals based on their marital status or human capital levels. .

Second bequest motives appear in the model as a way for workers to receive utility from inter generational transfers. Using the evolution of wealth over the life cycle, for each education and marital group, as primary source of identification for these preferences, we find that this motive is much stronger for college educated workers and those who are married. As bequests are modeled as a luxury good, college educated workers, who have higher income, also have stronger bequest motives. Additionally, married workers are more likely to have children and a desire to save wealth to bequeath to the next generation. Bequest motives highlight the difference between bequeathable wealth and Social Security benefits; private savings may be left in the form of bequests while Social Security benefits cannot.[4] This difference becomes important in the face of longevity risk. Individuals with strong bequest motives, who are nearing retirement in poor health, may fear dying relatively young. In that case, they will be induced to claim early in order to maximize the amount of private savings that can be left to their offspring.

Third, given the complicated nature of the Social Security system and the difficulty in accurately predicting ones own longevity, it seems likely that misinformation plays a role in individual's decisions. Previous literature has identified this mechanism and has found conflicting results on

[4]Of course married individuals can bequeath social security benefits to their spouses in the form of survivor's benefits.

the importance of it as a driving force of early claims.[5] Misinformation related to the penalties associated with early claims could push early claiming as individuals do not understand the monetary costs. Non-college educated workers are more likely to experience this misinformation. However, there are other forms of misinformation as well that workers face. Individuals do not have perfect information regarding their own longevity. As also discussed in Sun and Webb (2011) and Hurd et al. (2004), if workers believe they will die earlier, the trade-off between higher per year benefits and years of benefits received shifts. Workers are more likely to claim early if they believe they face lower survival chances. We estimate that this misinformation is stronger for college educated workers.

Finally, we estimate that agents in different education and marital groups also differ in the rate at which they discount the future. Single, non-college educated workers exhibit the lowest discount factor while college educated, married workers have the highest discount factor. This highlights a final behavioral channel, also highlighted in Gustman and Steinmeier (2005), Gustman and Steinmeier (2015), and Pashchenko and Porapakkarm (2018), which could induce higher early Social Security claims. As workers become more patient, they value the future stream of pension benefits relatively more and as a result less likely to claim early.

The structural model with all of these mechanisms and details of the Social Security program is estimated from Health Retirement Study and Panel Study of Income Dynamics data using Method of Simulated Moments. While most of the parameters, such as policy, earnings, and health, can be estimated cleanly without using the structural model, we target the evolution of wealth and labor supply over the life-cycle, for each education and marital group, to estimate the "deep" preference parameters. The model is able to replicate substantial early claims with roughly 60 percent of workers claiming Social Security benefits prior to the normal retirement age. Additionally, we find that the model can replicate the heterogeneity in claiming behavior by work status, education, health, and marital status. The model also does well in out-of-sample predictions for the Social Security claiming behavior of a cohort born ten years later.[6] With confidence in the structural model, we can perform counterfactual experiments to identify the relative importance of the aforementioned mechanisms.

Counterfactual experiments using the estimated model provides interesting insights related to aggregate claims as well as heterogeneity in claims across education types and marital status. First, precautionary motive, misinformation pertaining to rules and survival chances, and bequest motive, each have important effects on overall early claiming behavior – their elimination results in

[5]Papers in this literature include Greenwald et al. (2010) Liebman and Luttmer (2009) Liebman and Luttmer (2011) Coile et al. (2002) Benitez-Silve and Yin (2009) Diamond and Orszag (2004) Mastrobuoni (2010) Song and Manchester (2007)

[6]Specifically we use the 1941-1945 birth cohort for our validation exercise. This cohort observed a normal retirement age of 66, no earnings test starting age 65 and higher delayed retirement credit

roughly 12, 15 and 14 percentage points (p.p.) decline in early claims. At the same time, somewhat surprisingly, time discount rate has a much smaller effect by itself (increasing it results in a 1.4 p.p. decline in early claims and no impact on delayed claims). Second, all the aforementioned channels together can explain almost three-quarters of the age 62 claims (they go down from 35.7 to 10.1 p.p), roughly one-third of the total early claims (early claims go down from 75.1 to 48.4 percentage points) and increases delayed SS claims by roughly seven times.

Different education and marital groups react to these channels in very different ways with respect to their retirement and claiming decisions. In the absence of all these channels, singles in both education groups almost always claim at age 65. Early claims of married college graduates only go down 3.5 p.p. and infact *increase* by 15 p.p for the non-college married individuals. Despite higher longevities, wealth and insurance through spousal income, married individuals have an incentive to claim somewhat early as the spousal benefits are also connected to their claiming decisions. As a result, we observe a much stronger shift in claiming from age 62 and 63 to age 64 but not to the normal retirement age. However, those individuals who were already claiming at the NRA, now delay their claims further as seen by a 17 p.p increase in delayed claims for the married college graduates.

We also find that the strength of each channel differs for each marital and education group. While mortality misinformation has the largest impact on the claiming behavior of married college graduates, unemployment shocks and bequest motive are relatively more important for understanding the claiming behavior of singles. Finally, we find that while these channels by themselves or in combination explain why individuals claim early, it is clear that the decisions to delay claims remain largely governed by longevity. Married college graduates have the highest life expectancy at age 65 (roughly 19 years for our birth cohort) whereas non-college singles have the lowest at 12.6 years. So even in the absence of these shocks and misinformation, decisions to delay claims remain largely unaffected for those with lower life expectancy.

The paper proceeds as follows: Section 2 details empirical facts related to early Social Security claims. Section 3 describes the structural model. Section 4 describes the data used in the analysis. Section 5 details our structural estimation strategy. Section 6 discusses the results of the benchmark model and the counterfactual experiments. Section 7 provides concluding remarks.

2 Empirical Facts

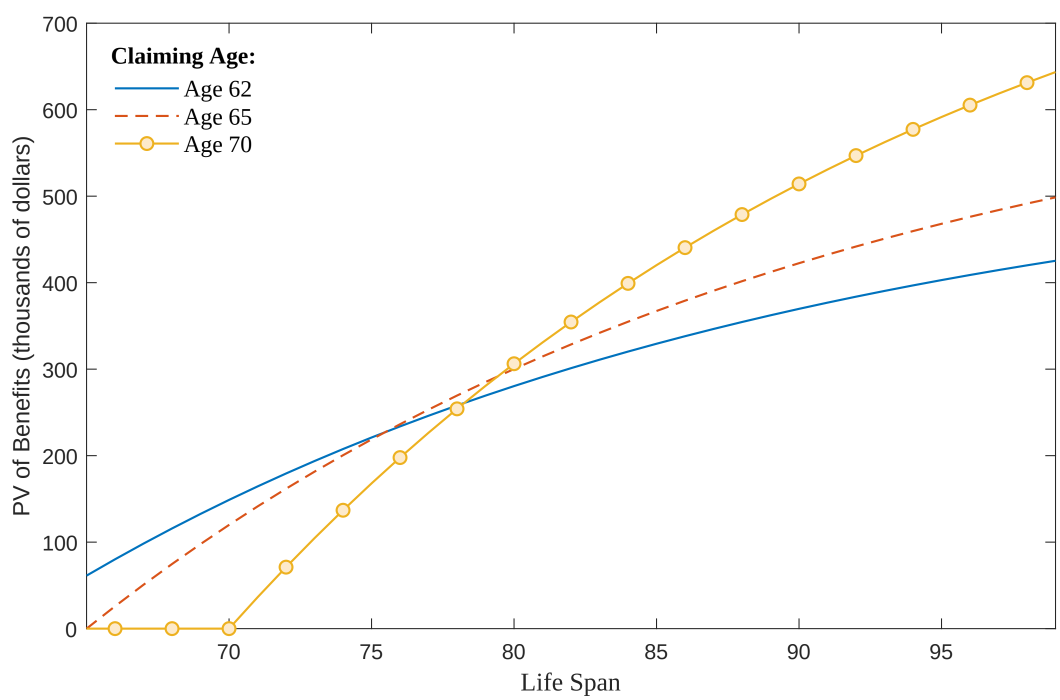
1. *Despite penalties, many workers claim Social Security benefits before the full retirement age*

   Claiming Social Security benefits before the full retirement age is associated with lower pension payments. Therefore, while early claimers may receive benefits for additional years, many retirees would receive lower total payments by claiming early. This is shown in Figure

1 which shows how the present value of benefits differs by length of life and claiming age.[7] Those with shorter life spans may benefit from early claiming as the extra years of benefits overwhelms the lower per period pension. However, as life spans increase the impact of the per period penalty adds up and leads to significantly lower total benefits when workers claim benefits at younger ages. As a 62 year old worker is expected to live for approximately 20 more years[8], many workers receive lower total benefits by choosing early retirement.

Despite this, many workers choose to claim benefits early. Figure 2 shows the distribution of claiming ages for male workers. As expected the distribution features two spikes: one at the early retirement age of 62 and one at the full retirement age of 65. While roughly 20 percent of retirees chose to claim benefits at age 65, nearly 45 percent of retirees chose to claim benefits at age 62. Including those who claimed at ages 63 and 64 indicates that almost 60 percent of workers elected to claim their Social Security benefits early despite the penalties.

Figure 1: Present Value of Social Security Benefits by Claiming Age

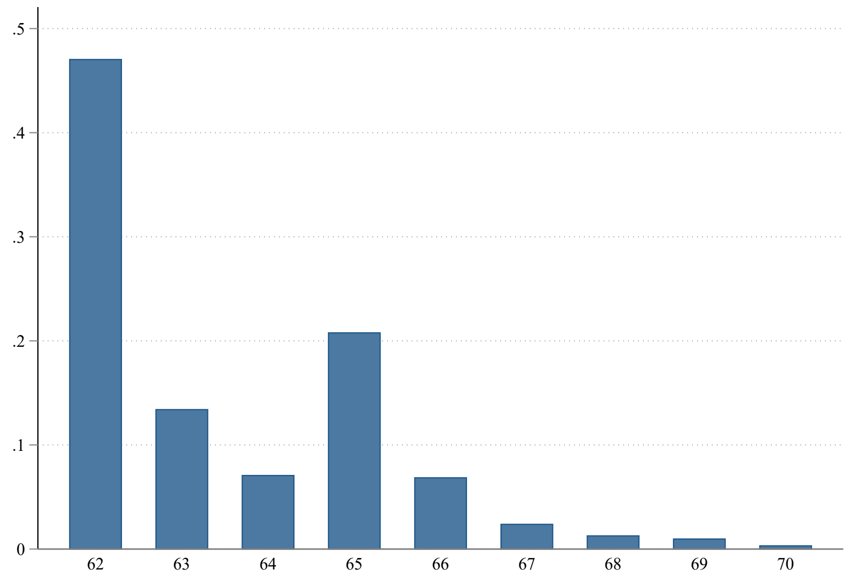


2. *The claiming decision is tied to the particpiation decision*

[7]This calculation holds constant the retirement income of the worker and assumes a discount factor of 0.964. This discount factor is calculated in Pashchenko and Porapakkarm (2018).

[8]This life expectancy is based on the Social Security Administration's actuarial life table. This table indicates that conditional on living to age 62, a male worker faces a 1.3% probability of dying within one year and a life expectancy of 20.08 years

Figure 2: Claiming Behavior by Age



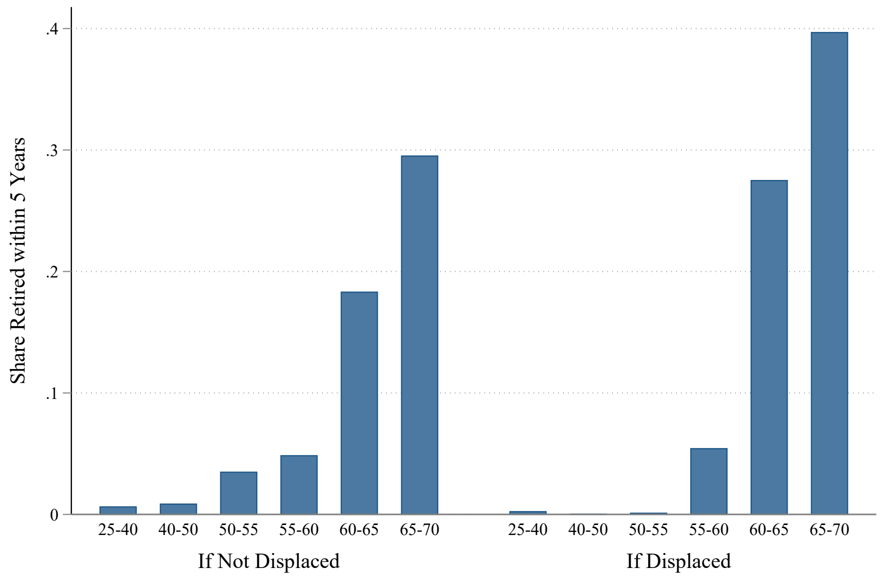
An important feature of the US Social Security system is that workers do not need to stop working in order to claim Social Security benefits. Rather, they may continue to receive a paycheck while also receiving pension benefits.[9] However, we document that many workers have already left the labor force prior to the decision to claim benefits–indicating that there is a link between the participation decision of a worker and the claiming decision of the worker. Additionally, this decision is not restricted to occurring in the same period. We document that many workers have chosen non-participation prior to choosing early claims.

In Figure 3, we document a connection between labor market displacements and a decision to retire in the PSID. Specifically, we compare the share of workers within an age group who are retired within five years across two group–those who experience a labor market displacement during that age range and those who do not. The figure demonstrates that a displacement events late in a workers' career increase the share of workers retired within five years by roughly 10 percentage points. Around 30 percent of those who working and experience a labor market displacement between the ages of 60 and 65 are retired witin 5 years compared with nearly 20 percent of those in the same age group who did not experience a displacement. For those between the ages of 65 and 70 these shares are around 40 percent and 30 percent for those who were displaced and those who were not, respectively.

Figure 4 shows that the link between labor market outcomes and labor force participation extends to the claiming decision. To create this, we run the following regression to study the

[9] The Social Security system does include an earnings test

Figure 3: Labor Exits



claiming behavior of individual i:

$$Pr[i \text{ claims before NRA}] = x_i'\beta + \sum_{k=-3}^{0} \delta_{ik} I_{ik}^{p} + \varepsilon_i \tag{1}$$

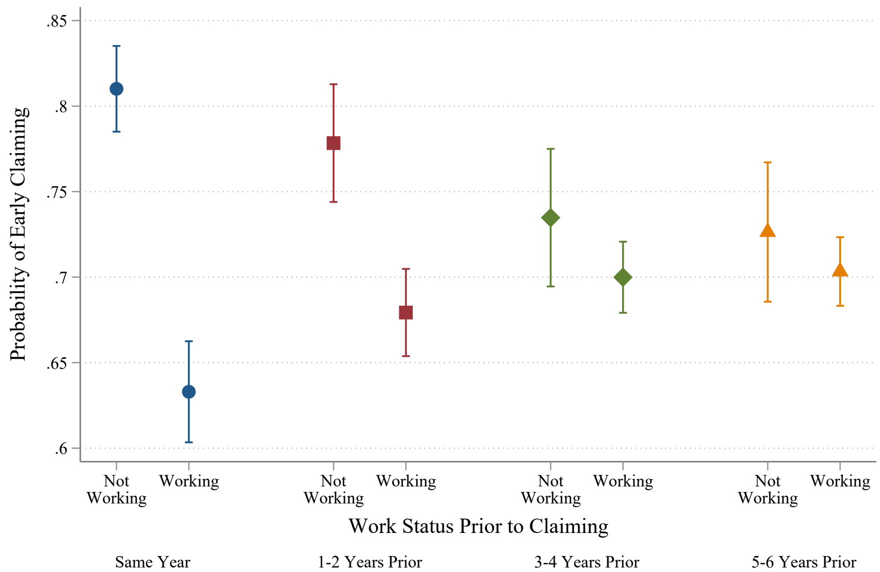
where the dependent variable is an indicator which takes a value of 1 if an individual claims Social Security benefits prior to the normal retirement age.[10] This indicator is regressed on a set of control variables x_i which includes education, race, gender, marital status, and an interaction between gender and marital status. Additionally, we regress the indicator of a series of dummy variables which represent whether a worker was working prior to claiming. We include dummies for participation in the year of claiming, one to two years prior, three to fours years prior, and five to six years prior.[11] Results of this regression for the impact of work status on early claiming are shown in Figure 4.

Results indicate that work status impacts claiming behavior. This results is decreasing as we consider lags further before the claiming age, but those individuals who are not working at during the same year of claiming, 1-2 years prior to claiming, and 3-4 years prior to claiming are more likely to claim prior to the normal retirement age.

[10]We also consider a case where rather than the indicator being for all claims prior to the normal retirement age we have an indicator for claims at the early retirement age of 62. These results are shown in Appendix C.1

[11]Because HRS is collectively biannually, we cannot include lags for every year. Additionally, we may not observe workers in the year they claim. Therefore, we consider a year after claiming age for these workers.

Figure 4: Probability of Early Claiming by Work Status



3. *Early claiming behavior is different based upon education level and health status.*

   Not all workers are equally likely to choose early benefit claiming. Rather, there are some demographic characteristics that are correlated with high probability of claiming benefits before the full retirement age. Two characteristics have a large impact on early claiming behavior: education level and self-reported health status. As we control for education and health status in Equation 1, the results of these characteristics on early claiming behavior are shown in Figure 5.

   Results indicate that those without a college degree are more likely to claim Social Security benefits prior to the normal retirement age.[12] Additionally, those in bad health are also more likely to claim prior to the normal retirement age. We also note that while there does not seem to be a significant difference in claiming behavior between those in fair and excellent health, there does seem to be a difference in claiming behavior between those in the best health and those in the worst health.[13] Finally, point estimates show that those who are single are slightly more likely to claim benefits before the normal retirement age but this impact is not statistically significant.[14] [15]

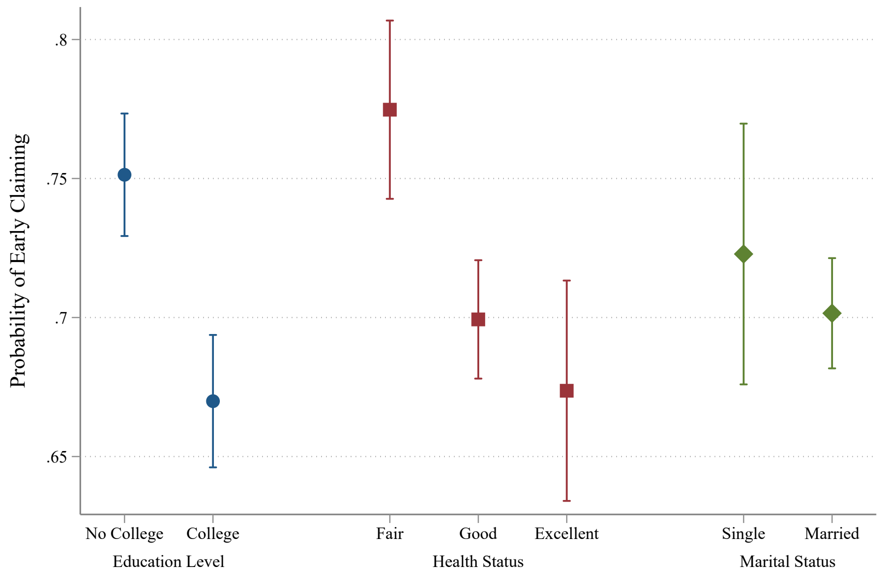
[12]We also considered using occupation rather than education as the control. There if a strong correlation between these controls. Details on the inclusion of occupation are considered in Appendix C.2

[13]We also experiment with including lags of health status in the regression. These results showed that health various years prior to claiming does not have a significant impact on claiming

[14]Shoven and Slavov (2014a) and Shoven and Slavov (2014b) also find that claiming behavior does not vary by marital status.

[15]However, this is likely due to interactions between these controls. In a regression which controls for only marital

Figure 5: Probability of Early Claiming by Education and Health



4. *There is notable misunderstanding on the rules assoiated with early benefit claims*

   Table 1 details misunderstanding of the penalty associated with early Social Security claims. Specifically, we measure misunderstanding based upon whether a worker believes there is no penalty for early claims.[16] We document that not only does a significant fraction of workers believe there is no penalty for claims prior to the normal retirement age, but also this fraction who misunderstand the system varies across education levels. Among those with a college education, roughly 22 percent of workers believe there is no penalty for early claims. This fraction is nearly 9 percent for college educated individuals. Therefore, many individuals are not informed about the penalties related to early Social Security benefit claims.[17]

3 Model

This section presents a dynamic programming model of retirement and Social Security. In order to capture the true nature of retirement incentives for older workers, retirement benefits from Social Security are modeled in great detail to match that of the current U.S. system.

status, the difference in claiming behavior between singles and married are larger and point estimates are statistically different from one another.

[16]This measure does not take a stand on the degree of misunderstanding or whether those who understand there is a penalty know the percentage penalty.

[17]This may be a reason that papers, such as Shoven and Slavov (2014a), Shoven and Slavov (2014b), and Goda et al. (2015) find that even those with enough wealth to delay claims choose to claim early.

Table 1: Misunderstanding by Education

	Fraction who believe there is no penalty for early claims
No College	21.8
College	8.7

Labor supply (h_t), consumption (c_t), savings (a_{t+1}) and Social Security benefit application (b_t^{ss}) of a male household head is modeled. Individuals make these decisions in every time period t and adjust their behavior in response to uncertainty pertaining to employment, wages, health, and survival.

Individual's life cycle from ages $t = 25, 26, ..., 99$ is modeled. Individuals are heterogeneous with respect to both permanent and evolving staes. Agents are permanently different with respect to their fixed education type (e), marriage (q), and SS program knowledge type (k). Marriage is summarized by a pair (m, ι) where m is a variable indicating if the agent is single or married and ι denotes the age gap between spouses if the individual is married. Evolving states include stochastic labor productivity (η_t), employment status (λ_t), health status (μ_t), assets (a_t), social security wealth (a_t^{ss}) and application status (b_{t-1}^{ss}). Given this vector of states $\mathbf{z_t} = \left(e, q, k, \eta_t, \lambda_t, \mu_t, a_t, a_t^{ss}, b_{t-1}^{ss}\right)$, individuals choose optimal consumption, labor supply and make Social Security benefit application decisions (if eligible) to maximize the present discounted value of life-time utility.[18]

The dynamic programming model has various components. The following sections describe each model ingredient in detail.

3.1 Preferences

Agents in period t derive utility from consumption c_t and leisure l_t. The within period utility is non-separable between consumption and leisure and is given as follows.[19]

$$U^{e,m}(c_t, l_t) = \frac{1}{1-\rho^{e,m}} \left(\left(\frac{c_t}{\zeta_t^{e,m}} \right)^{\nu^{e,m}} l_t^{1-\nu^{e,m}} \right)^{1-\rho^{e,m}}$$

[18]Note that Social Security application is a one-time decisions in the model which cannot be reversed.

[19]The paper follows French and Jones (2011), French (2005), Casanova (2010) and others in addressing the "Retirement-Consumption puzzle". A decline in consumption at retirement is caused by both- 1) unexpected health shocks to leisure causing unplanned retirement and 2) non-separability of preferences between consumption and leisure.

Where $\rho^{e,m}$ is the coefficient of relative risk aversion and $\nu^{e,m}$ is the weight on consumption. ζ_t^m is the equivalent scale in consumption. Each of these parameters vary by both education (e) and marital status (m). The total amount of leisure in period t is given by:

$$l_t = \bar{l}^{e,m} - h_t - \phi_P^{e,m}(t)\mathbb{I}\{h_t > 0\} - \phi_H^{e,m}(t)\mathbb{I}\{\mu_t = \text{fair}\} \tag{2}$$

Where $\bar{l}$ is the total endowment of leisure each period, h_t is hours worked, function $\phi_H^{e,m}$ determines the amount of leisure lost due to a bad health shock and $\phi_P^{e,m}$ determines the participation cost incurred if hours worked h_t are positive.

Upon dying an individual values bequests of any leftover bequeathable wealth, A_t, according to the utility function developed by De Nardi (2004)

$$beq^{e,q}(A_t^q) = \frac{\theta_{beq}^{e,m}}{1-\rho^{e,m}}\left(A_t^q + \kappa_{beq}^{e,m}\right)^{(1-\rho^{e,m})\nu^{e,m}}$$

Bequeathable wealth, A_t^q, is equal to any assets that remain, a_t, and Social Security survivors benefits, if eligible. Eligibility for survivors benefits is dependent on marriage, q.[20] The coefficient $\theta_{beq}^{e,m}$ measures the strength of bequest motive and $\kappa_{beq}^{e,m}$ measures the curvature of bequest function. Increase in $\theta_{beq}^{e,m}$ increases the marginal utility of a unit of bequest and increase in $\kappa_{beq}^{e,m}$ indicate that the bequest is valued more like a luxury good. These parameters are permitted to vary by education level, e, and marital status, m.

3.2 Health and Mortality

Every period individuals are subject to an exogenous education specific health shock. Health affects individuals in multiple ways – affects the survival probability for the next period, wages and the total time endowment of leisure. The transition probability for health depends on current health status, education level, and age in the next period. The transition between two states i and j is given by:

$$\pi_{t+1}^{\mu_{ij}} = prob(\mu_{t+1} = j | \mu_t = i, e, t+1)$$

Individuals are also subject to mortality shocks in each period. The survival probability for the next period depends on age next period and current health status as given below:

$$\pi_{t+1}^{s} = prob(s_{t+1} = 1 | \mu_t, m, t+1)$$

[20]More details on survivors benefits is discussed in Section 3.5.3

3.3 Employment

An individual experiences unemployment shocks with probability π^{λ}. Unemployment shocks lower labor productivity and create wage scarring effects in the model (see section 3.4).

$$\pi_{t+1}^{\lambda} = prob(\lambda_{t+1} = 1)$$

3.4 Wages

Hourly wage in every time period is a function of education, health, and age specific profile $\omega(e, \mu_t, t)$, unemployment status (λ_t) and an autoregressive component η_t.[21]

$$\begin{aligned} w_t &= \zeta(\lambda_t)\exp(\omega(e, \mu_t, t) + \eta_t) \\ \eta_t &= \rho^w \eta_{t-1} + \epsilon_t^w \\ \epsilon_t^w &\sim N(0, \sigma_{\epsilon^w}^2) \end{aligned} \tag{3}$$

If the individual experiences an unemployment shock $\lambda_t = 1$ then he may immediately re-enter the labor market but experiences a wage penalty, $\zeta(\lambda_t)$.

3.5 Social Security

The Social Security system in the U.S. provides retirement incentives at the time when these benefits become available. The actual benefits are computed in several steps. First the earnings of the 35 highest earning years are averaged into an index — Average Indexed Monthly Earnings (AIME). The AIME increases by working an additional year if earnings in that year is higher than the lowest earnings embedded in it and is also capped at some threshold.

Let a_t^{ss} be the Social Security wealth in the model (annualized measure of AIME). Then the Social Security wealth evolution is approximated in the model in the following simple way:

$$a_{t+1}^{ss} = \max\{[(1 + g_{awi}\{t \leq 60\})a_t^{ss} + \max\{0, (w_t h_t - (1 + g_{awi}\{t \leq 60\})a_t^{ss})/35\}], a^{\max}\} \tag{4}$$

Where $a^{\max}$ is the threshold at which the Social Security wealth is capped and g_{awi} captures the indexing of the Social Security benefits for real wage growth and $w_t h_t$ denotes annual earnings for period t.[22] Note that in equation 4, we assume that the high earnings year only replaces an average

[21] This specification provides reasonable wage scarring effects of unemployment spells in the model.

[22] Note that in practice, a worker's annual nominal earnings each year are indexed to economy wide earnings as of the year the worker turns age 60, which is accomplished by multiplying the annual nominal earnings by the ratio of the national Average Wage Index (AWI) in the year the worker turns 60 to the AWI in the year the nominal earnings were paid.

earnings year as modeling the actual system would require keeping track of entire earnings history which is computationally infeasible. AIME is converted to obtain the Primary Insurance Amount (PIA) which determines the Social Security benefits using the following piece-wise linear function:

$$pia(a_t^{ss}) = 0.90 \times \min\{a_t^{ss}, b_0\} + 0.32 \times \min\{\max\{a_t^{ss} - b_0, 0\}, b_1 - b_0\} \\ +0.15 \times \max\{a_t^{ss} - b_1, 0\} \quad (5)$$

The Social Security system in the model provides several work disincentives at older ages. For instance, the Social Security wealth a_t^{ss} is only recomputed upwards if current earnings are greater than average past earnings (as shown in equation 4). For instance, staying longer in the labor market by working part-time may not increase the benefits for the individuals in the model.[23] Additionally, there are strong work disincentived due to penalty/reward system associated with the timing of SS application and earnings test as described below.

3.5.1 Adjustments

Social Security benefits, ssb_t, are a function of this PIA and two possible adjustments: a penalty for claiming early (or benefit for claiming late) and decrease in benefits for those workers who continue working while claiming benefits.

$$ssb_t = pia(a_t^{ss}) * \underbrace{(1 - \Gamma_t)}_{\text{Early/Late Claim Penalty}} - \underbrace{\Upsilon_t}_{\text{Earnings Test}} \quad (6)$$

Discussion of each of these adjsutments is below.

Early/Late Claiming Penalty $(1 - \Gamma_t)$

SS benefits can be claimed without any penalty at the normal retirement age (t_{NRA}) which is age 65 in the model.[24] However, individuals can claim benefits with some penalty starting the Early Retirement Age (t_{ERA}) which is age 62. For every year before the NRA that these benefits are claimed, the Social Security amount received by an individual is permanently reduced by a certain fraction. Individuals can also delay their benefit claim beyond NRA. In that case, future benefits are permanently increased by a certain amount. It has been largely argued in the literature

[23]In practice, the highest 35 years of covered earnings are used to compute AIME. If the individual has not yet worked for 35 years, some zeros are included in the average, and any positive earnings, including part-time work, will increase the AIME.

[24]The NRA is slightly different for different birth cohorts. For instance, the sample used in this analysis, observed an average NRA of 65. But later cohorts observed an NRA of 66 or 67. The details on NRA changes is contained in appendix table (C.3)

(Heiland and Yin, 2014; Gruber and Wise, 2005) that while the benefit reductions due to early claim are actuarially fair, the delayed claim benefit increase does not fully compensate the beneficiary for the loss in benefits in the previous periods, hence, are not actuarially fair. This structure of the Social Security system thus provides strong incentives to claim benefits at the earliest possible.[25]

This penalty shows up at a percentage decrease γ_t^{ss} for each year prior to the normal retirement age that a worker claims or a percentage increase for each year after the normal retirement age that a worker delays claiming.

$$\Gamma_t = \begin{cases} \gamma_t^{ss} * (t_{NRA} - t) & \text{if } t < t_{NRA} \\ 0 & \text{if } t = t_{NRA} \\ -\gamma_t^{ss} * (t - t_{NRA}) & \text{if } t > t_{NRA} \end{cases} \tag{7}$$

Earnings Test Υ_t

Social Security earnings test taxes the labor income, above a certain threshold y_t^{ss}, of the Social Security beneficiaries at a rate τ_t^{ss}, till the age of 70. Specifically, for each additional dollar earned above the threshold, Social Security benefits are reduced by τ_t^{ss}, until all benefits are taxed away as shown below:

$$\Upsilon_t = \min\{pia\left(a_t^{ss}\right), \max\{0, w_t h_t - y_t^{et}\}\tau_t^{et}\}$$

Where Υ_t denotes benefits lost through the earnings test. Taxed benefits are credited back through permanent increases in future benefits, which is implemented in the model through increases in the Social Security wealth as shown below:[26]

$$\begin{aligned} ssb_{t+1} = pia(a_{t+1}^{ss}) * \left[1 + \left(\frac{\Upsilon_t}{ssb_t}\right)\gamma_t^{ss}\right] \\ a_{t+1}^{ss*} = pia^{-1}(ssb_{t+1}) \end{aligned} \tag{8}$$

Where γ_t^{ss} is the same reduction/increment factor which is used for determining penalty/credit for early/late benefit application as discussed earlier. The net work incentives provided by earnings test crucially depends on γ_t^{ss} which determines whether the future increases in benefits are actuarially fair or not. It has been argued that the crediting rate is less than actuarially fair after age 64.[27] As a result, the earnings test combined with the benefit application age structure may provide strong

[25] The actual incentives may also depend on a variety of other factors like an individual's subjective mortality expectations, heterogeneous discount factors etc.

[26] Note that this is a simplification as in practice, the benefits are typically adjusted upon reaching the NRA.

[27] Note that the earnings test was removed for the age-group 65-69 starting in 2000.

incentives to retire upon reaching the claiming age. Since the Social Security rules have been changing over time, the specific rules pertinent to the sample used in this analysis are used from SSA.

3.5.2 Perceived Social Security Benefits

We model permanent heterogeneity in SS program knowledge (k) regarding penalty/credit for early/late application. Specifically we allow two groups of individuals where one group is fully informed about the rules and the other group assumes there is no early claiming penalty or late claiming benefit while making their decisions. Therefore, we define perceived Social Security benefits, $\overline{ssb}_t$, based on whether an individual understand the rules or not.

$$\overline{ssb}_t = \begin{cases} ssb_t & \text{if } k = \text{informed} \\ pia\left(a_t^{ss}\right) & \text{if } k = \text{uninformed} \end{cases} \tag{9}$$

In short, if the individual is informed, the Social Security benefits received are identical to those calculated by the system, or $\overline{ssb}_t = ssb_t$. If, on the other hand, the individual is uninformed about the rules, the perceived benefits do not include the adjustments for the early or late claims or the earnings test. In this case, the perceived benefits are equivalent to the primary insurance amount, or $\overline{ssb}_t = pia\left(a_t^{ss}\right)$.

3.5.3 Marriage Related Benefits

Spousal Benefits

Married households have the option of additional income through Social Security spousal benefits. Through the program, workers are entitled to up to 50 percent of the primary insurance amount of their spouse through Social Security benefits. Final benefits received are equal to $\delta_t^q \overline{ssb}_t$ where δ_t^q ranges between values of 1 (for singles) to 1.5 (for married couples without adjustments to spousal benefits).

More specifically, spousal benefits received depend upon marital status and spousal age. Spousal age is determined by the difference between the individuals age, t, and the age gap between spouses, ι. Benefits are calculated by the following formula:

$$\delta_t^q = \begin{cases} 1.0 & \text{if } m = \text{single or } m = \text{married}, t - \iota < t_{ERA} \\ 1.5 * \left[1 - \gamma_t^{ss} * \left(t_{NRA} - (t - \iota)\right)\right] & \text{if } m = \text{married}, \ t_{ERA} \leq t - \iota < t_{NRA} \\ 1.5 & \text{if } m = \text{married}, \ t - \iota \geq t_{NRA} \end{cases} \tag{10}$$

Single individuals and married individuals who's spouse is not yet eligble for benefits ($t - \iota < t_{ERA}$) receive no additional spousal benefits. Married individuals in which the spouse's age is above the early retirement age but below the normal retirement age receive benefits penalized by the same percentage in Section 3.5.1. A married individual who's spouse is older than the normal retirement receives the additional 50 percent of benefits.

Survivors Benefits

Married individuals may also leave their Social Security benefits to a spouse in the case of their death. These survivors benefits enter into the bequeathable wealth of individuals, A_t^q, where bequeathable wealth takes the following form:

$$A_t^q = \begin{cases} a_t + \sum_{j=t-\iota}^{T} \frac{1}{1+r} \pi_{j+1}^s ssb_t & \text{if } m = \text{married}, \; b_t^{ss} = 1 \\ a_t & \text{otherwise} \end{cases} \tag{11}$$

If addition to any leftover wealth, a_t, married individuals may also leave behind additional wealth in the form of Social Security survivors benefits. Therefore, bequeathable wealth is a function of Social Security wealth if $m =$ married and the individual has already chosen to claim benefits, $b_t^{ss} = 1$.[28] These survivors benefits are calculated as the present value of the stream of benefits a spouse would receive from the death of their spouse and the terminal age (99). Therefore, this present value is a function of the worker's age t and the age gap between spouses, ι.

3.6 Government

The government finances the Social Security system through payroll taxes. Individuals also pay labor income taxes. Government transfers tr_t bridge the gap between some minimum level of consumption and individual's liquid resources. This is a simple approximation to the federal safety net programs in the U.S. like Supplemental Nutritional Assistance Program (SNAP), Supplemental Security Income (SSI), Temporary Assistance for Needy Families (TANF) etc.

$$tr_t = \min\{0, \underline{c} - (a_t + y_t + \delta_t^q ssb_t)\} \tag{12}$$

[28]It is assumed that is an individual dies prior to claiming Social Security benefits their spouse is not eligible for survivors benefits. As death is uncommon prior to age 62, this is a reasonable assumption

3.7 Budget Constraint

Prior to claiming Social Security benefits, individuals make decision based upon a budget constraint which includes the perceived Social Security benefits. This budget constraint is:

$$c_t + a_{t+1} = a_t + W\left(y_t, y_{st}, \overline{r}a_t, \tau\right) + \mathbb{I}\left\{b_t^{ss} = 1\right\} \times \delta_t^q \overline{ssb}_t + tr_t \tag{13}$$

An individual's household income, $W\left(\cdot\right)$, consists of various components. He receives income through hours worked in the labor market $w_t h_t$, spousal income y_{st} if the individual is married, interest on assets ra_t. Additionally, he believes that he will receive Social Security benefits $\nu_t^m \overline{ssb}_t$ once he claims. Finally, if eligible, the individual receives transfers from the government, tr_t.

Once, the individual claims benefits (i.e. $b_t^{ss} = 1$), the true Social Security benefits are revealed to him. Then, the budget constraint becomes:

$$c_t + a_{t+1} = a_t + W\left(y_t, y_{st}, \overline{r}a_t, \tau\right) + \delta_t^q ssb_t + tr_t \tag{14}$$

Labor income, y_t, is a function of the wage, the labor choice of the individual, and ther employment status in the model. If the worker receives the employment shock, $\lambda_t = 1$, he may re-enter the labor market immediately, but his earnings are penalized by the amount ψ.

$$y_t = \begin{cases} \psi w_t h_t & \text{if } \lambda_t = 1 \\ w_t h_t & \text{if } \lambda_t = 0 \end{cases} \tag{15}$$

Spousal income is determined as a function of an individual's education, age and wage in the model and given as follows:

$$y_{st} = f\left(e, q, t, w_t\right) \tag{16}$$

There is a borrowing constraint on assets given by:

$$a_{t+1} \geq 0 \; \forall t \tag{17}$$

and a consumption floor which guarantees a minimum level of consumption (Hubbard et al., 1995).

$$c_t \geq \bar{c} \tag{18}$$

3.8 Recursive Formulation

Let $\mathbf{z_t} = \left(e, q, k, \eta_t, \lambda_t, \mu_t, a_t, a_t^{ss}, b_{t-1}^{ss}\right)$, be the period t state vector. Then individuals solve a finite-horizon Markovian decision problem where they choose a sequence of consumption $\{c(\mathbf{z_t})\}_{t=1}^{T}$, hours $\{h(\mathbf{z_t})\}_{t=1}^{T}$ and Social Security benefit application $\{b^{ss}(\mathbf{z_t})\}_{t=1}^{T}$ rules to maximize the expected discounted lifetime utility subject to the exogenous processes for health transition, employment shocks, survival, and wage determination, a set of budget, borrowing, and time constraints, government transfer rule, and policies for taxes and Social Security.

The life-cycle of an individual between ages 25 and 99 is divided into three distinct phases. The first is the *employment* phase between ages 20 and 61 where individuals make consumption, savings and employment decisions.[29].The second is the *retirement choice* phase between ages 62 and 69 where individuals also make Social Security application decisions (b_t^{ss}) and finally the *retired* phase where individuals only make consumption and savings decision. The decision problem of an education level e, marital status m, and Social Security understanding k for each phase is given below:

3.8.1 Employment phase

$$
\begin{aligned}
V_{e,q,k}(a_t, a_t^{ss}, \eta_t, \lambda_t, \mu_t) = \max_{\{c_t, h_t\}} \Bigg\{ & U^{e,m}(c_t, l_t) \\
& + \beta^{e,m} \pi_{t+1}^{s} \Big[EV_{e,q,k}(a_{t+1}, a_{t+1}^{ss}, \eta_{t+1}, \lambda_{t+1}, \mu_{t+1}) \Big] \\
& + \beta^{e,m}(1 - \pi_{t+1}^{s}) beq^{e,m}(A_{t+1}^{q}) \Bigg\} \quad s.t.
\end{aligned}
$$

$$
a_{t+1} = a_t + W(y_t, y_{st}, \bar{r}a_t, \tau) + tr_t + \delta_t^q \overline{ssb}_t \times \mathbb{I}\left\{b_t^{ss} = 1\right\} - c_t,
$$

(2), (4-8), (17), and (18).

Where $y_t + y_{st} + \bar{r}a_t$ is the total pre-tax income and $W(., \tau)$ gives the level of post-tax income with the tax rate τ. Note that the expectation is taken with respect to wage, employment and health uncertainty.

3.8.2 Retirement choice phase

If the individual enters the period as a non-claimer, he faces the decision of whether to claim this period.

[29] We do not allow individuals to claim disability

$$V_{e,q,k}(a_t, a_t^{ss}, \eta_t, \lambda_t, \mu_t, b_{t-1}^{ss}=0) = \max\left\{V_{e,q,k}^{b_t^{ss}=0}, V_{e,q,k}^{b_t^{ss}=1}\right\}$$

$$\begin{aligned} V_{e,q,k}^{b_t^{ss}=0}(a_t, a_t^{ss}, \eta_t, \lambda_t, \mu_t, b_{t-1}^{ss}=0) = \max_{\{c_t, h_t, b_t^{ss}\}} \Bigg\{ & U^{e,m}(c_t, l_t) \\ & + \beta^{e,m}\pi_{t+1}^{s}\Big[EV_{e,q,k}(a_{t+1}, a_{t+1}^{ss}, \eta_{t+1}, \lambda_{t+1}, \mu_{t+1}, b_t^{ss}=0)\Big] \\ & + \beta^{e,m}(1-\pi_{t+1}^{s})beq^{e,m}(A_{t+1}^{q})\Bigg\} \quad s.t. \end{aligned}$$

$$a_{t+1} = a_t + W(y_t, y_{st}, \bar{r}a_t, \tau) + tr_t + \delta_t^q \overline{ssb}_t \times \mathbb{I}\{b_t^{ss}=1\} - c_t,$$

(2), (4-8), (17), and (18).

$$\begin{aligned} V_{e,q,k}^{b_t^{ss}=1}(a_t, a_t^{ss}, \eta_t, \lambda_t, \mu_t, b_{t-1}^{ss}=0) = \max_{\{c_t, h_t, b_t^{ss}\}} \Bigg\{ & U^{e,m}(c_t, l_t) \\ & + \beta^{e,m}\pi_{t+1}^{s}\Big[EV_{e,q,k}(a_{t+1}, a_{t+1}^{ss}, \eta_{t+1}, \lambda_{t+1}, \mu_{t+1}, b_t^{ss}=1)\Big] \\ & + \beta^{e,m}(1-\pi_{t+1}^{s})beq^{e,m}(A_{t+1}^{q})\Bigg\} \quad s.t. \end{aligned}$$

$$a_{t+1} = a_t + W(y_t, y_{st}, \bar{r}a_t, \tau) + tr_t + \delta_t^q ssb_t - c_t,$$

(2), (4-8), (17), and (18).

3.8.3 Retired phase

$$\begin{aligned} V_{e,q}(a_t, a_t^{ss}, \mu_t) = \max_{c_t}\Bigg\{ & U^{e,m}(c_t, l_t) + \beta^{e,m}\pi_{t+1}^{s} EV_{e,q}^{j}(a_{t+1}, a_{t+1}^{ss}, \mu_{t+1}) \\ & + \beta^{e,m}(1-\pi_{t+1}^{s})beq^{e,m}(A_{t+1}^{q})\Bigg\} \quad s.t. \end{aligned}$$

$$a_{t+1} = a_t + W(y_{st}, \bar{r}a_t, \tau) + \delta_t^q ssb_t + tr_t - c_t,$$

(2), (5), (17), and (18).

4 Data

The Health and Retirement Study (HRS) is a longitudinal study of Americans over the age of 50. Version O is used in this work. Importantly, the survey contains questions related to retirement and Social Security claiming decisions. The sample used covers workers within the HRS cohort; this cohort contains workers born between 1931 and 1941.[30] This work focuses on a sample of 86,823 male workers.

We use the Household Component of Medical Expenditure Panel Survey (MEPS-HC) to identify health and mortality related parameters. MEPS-HC is a nationally representative survey of the U.S. civilian noninstitutionalized population. The sampling frame is drawn from respondents to the National Health Interview Survey (NHIS), which is conducted by the National Center for Health Statistics.

Estimation regarding earnings and employment outcomes are calculated using the Panel Study of Income Dynamics (PSID). PSID is a longitudinal data set covering years 1968-2017 which contains detailed information on earnings and employment.[31] The sample used for analysis covers male household heads between the ages of 25 and 70 for the years 1984-2017.[32] Observations which are in the top or bottom 1 percent in the distribution of labor income are dropped. This leaves a final sample of 96,853 observtions on 13,278 individuals.

The Understanding America Survey (UAS) is used to study what percentage of workers understanding the Social Security rule and the penalty associated with early benefit claims. UAS is a panel dataset of roughly 9,000 respondent representing the United States. The panel is an internet study where respondent can respond digitally whenever they choose. We use a sample of 5,388 observations in this work. This dataset is used to measure the degree to which individuals understand the Social Security system.

5 Estimation

We estimate our model for male household heads born between 1931-1935 using a two step estimation strategy following Gourinchas and Parker (2002). In the first step, we use several datasets like PSID, HRS, MEPS and UAS to estimate processes which can be identified without using the dynamic programming model. We call this vector Φ which includes health transitions, survival probabilities, wages, unemployment probabilities, knowledge about social security rules, tax func-

[30]There are other cohorts contained with HRS. This cohort is used as we can see the full information related to retirement decisions

[31]The survey was conducted annually between 1968 and 1997 and bi-annually since then.

[32]The final sample uses data beginning in 1984 as this is when PSID began collecting information on self-reported health.

tion etc. In the second step, we use initial conditions drawn from data for the relevant cohort, our structural model and the parameters from the first step to estimate the preference parameter vector $\Theta = \{\beta^{e,m}, \rho^{e,m}, \nu^{e,m}, \theta_{beq}^{e,m}, \phi_H^{e,m}(t), \phi_P^{e,m}(t)\}$ using Method of Simulated Moments (MSM). The following sections describe both the first and second steps in detail.

5.1 First Step Estimation

5.1.1 Health and Mortality

Health can take three possible values, $\mu_t = \{\text{excellent}, \text{good}, \text{poor}\}$, in the model. We identify these health states in the Medical Expenditure Panel Survey data from the self-reported health status variable.[33] Health transitions across these states are then estimated by running an ordered probit of self-reported health status on previous year health status, education, and a quadratic function of age.

Survival probabilities in the model vary with age, education, marital status, and health status ψ_{jeh}. These probabilities cannot be directly derived from MEPS as it does not sample the institutionalized population. Moreover, given the limited sample size for each birth cohort, these probabilites cannot be estimated reliably for different birth cohorts. So we obtain cohort- education- marital status- and health- specific survival rates in the following two steps. First, we estimate the raw age-, education-, marital status-, and health-specific profiles from the MEPS data by running an ordered probit model of death indicator on self-reported health status, age quadratic, education, and marital status as mentioned earlier. In a second step, we adjust these profiles to match life expectancy at age 65 for both education groups for our benchmark birth cohort (those born in between 1931 to 1935).[34]

5.1.2 Employment Shock, Re-entry Costs, and Wage Scarring

The employment shock is the exogenous proability that a workers is separated from the labor market. We allow this probability to depend upon the education level of the individual. We set this employment shock, λ, to match the separation rate measured in JOLTS.[35,36]

[33] The Medical Expenditure Panel Survey asks respondents to self report their health on a scale of 1 to 5 where 1 is “Excellent”, 2 is “Very Good”, 3 is “Good”, 4 is “Fair”and 5 is “Poor”. For computational simplicity, the 5-point scale is converted into a 3 point scale by grouping individuals of “Very Good” and “Good” health into the good health category and those in “Fair” and “Poor” into the “poor” category

[34] Data on LE : https://www.ssa.gov/policy/docs/workingpapers/wp108.html

[35] This is not what we currently have, but this is definitely what we should do.

[36] JOLTS provides data on separations at the industry level. In order to construct the separation rate by education we use the share of college graduates within each industry to assign separations and employment. Additionally, due to data years available, this calculation is for 2001-2019.

The wage penalty associated with the employments shock, ξ, is modeled as a percentage of income. The penalty is estimated from PSID following the literature on the wage scarring.[37] To estimate the penalty of a displacement, the log of hourly wages is regressed on dummies representing years since a labor force displacement occur as well as a vector of control variables including a quadratic in age and a quadratic in experience. This penalty is set to be the percentage drop in annual wages that displaced workers experience.

5.1.3 Labor productivity

As shown, wages are assumed to be comprised of a profile which is a function of age, education level, and self-reported health status and a persistent shock. This function of age, education, and health is estimated from PSID. Discussion of this estimation and the estimation of the parameters of the stochastic process are detailed in Appendix B.1.

5.1.4 Social Security

We choose to explicitly model the rich detail of the U.S. Social Security System (described in Section 3.5). This requires us to define the parameters involved with these modeling choices. Table (2) shows these parameters based on the 1998 rules from the United States Social Security Administration.

The first group of parameters, b_0, b_1, and a^{max}, are related to the calculation of Social Security wealth and benefits. The maximum wealth at which benefits are capped is given by a^{max} and is set at $68,400. The parameters b_0 and b_1 define the bend points of the Social Security benefits formula, $g(\cdot)$. These points are set to $5,724 and $34,500. There is no variation in these parameters based upon the claiming age of the worker.

The second group of parameter are based upon the earnings test. Before the natural retirement age, earning above $9,120 are taxed at a rate of 50 percent. After the normal retirement age, earnings above $14,500 are taxed at a 33 percent rate.[38]

The final parameter of Table (2) defines the penalty for early claiming (or the benefit for delaying claiming). Because workers have reached the normal retirement age, per period benefits are decreased by 6.7 percent for each year early the worker claims. After the normal retirement age, benefits are increased by 5.5 percent for each year the worker delays benefit claims.

[37] Papers in this literature include Jacobson et al. (1993), Huff Stevens (1997), and Huckfeldt (2016)

[38] This normal retirement age is dependent on birth cohort. It is age 65 for our benchmark birth cohort (born in 1931-35)

Table 2: Social Security Benefit Formula

Parameter	Value*	
	before the NRA	after the NRA
a^{max}	68,400	68,400
b_0	5,724	5,724
b_1	34,500	34,500
Earnings Test		
y^{et}	9,120	14,500
τ^{et}	0.50	0.33
γ_t^{ss}	0.067	0.055

*1998 rules from the SSA and those pertaining to the 1931-1935 birth cohort.

5.1.5 Taxes

Individuals in the model pay a proportional payroll tax (τ_t^{ss}) and labor income taxes. Following the literature, we adopt a smooth functional form that allows for negative tax rates in order to incorporate Earned Income Tax Credit (EITC). We allow the function to vary by education and birth cohort and estimate the following function from the PSID data:

$$\tau^e = 1 - \lambda^e y^{-\xi^e}.$$

We allow for the tax function to differ by education type to capture any differences in family size across these two groups. The proportional labor income tax (τ_t^{ss})

5.1.6 Misunderstanding on the Social Security System

We model misunderstanding of the Social Security system as a fixed type. We use the Understanding America Study to estimate the fraction of workers who believe that the age at which they begin claiming has no impact on the benefits received. As previously shown in Table 1, we estimate that roughly 22 percent of non-college educated workers are misinformed while nearly 9 percent of college educated individuals do not understand the policy.

5.2 Second Step Estimation

Given the vector of exogenous data generating processes Φ and the vector of preference parameters Θ as described above, the decision rules $c(z_t, \Phi, \Theta)$, $h(z_t, \Phi, \Theta)$, and $b^{ss}(z_t, \Phi, \Theta)$ are solved numerically using backward induction. The estimated Φ and initial conditions z_0 are then used to simulate the life cycle profiles of hypothetical individuals. Finally, an MSM criterion function is used to find $\hat{\Theta}$ that minimizes the distance between aggregated simulated and data profiles. The following moments are matched to estimate the elements of Θ:

1. Labor market participation of male household heads between ages 25 and 69 for both non-college and college graduates resulting in 90 moment conditions.

2. Log of hours worked conditional on participation of male household heads between ages 25 and 69 for both non-college and college graduates resulting in 90 moment conditions.

3. Mean assets of male household heads between ages 25 and 80 for both non-college and college graduates resulting in 110 moment conditions.

This gives a total of 290 moment conditions. Formally the MSM estimate $\hat{\Theta}_{MSM}$ is one that solves:

$$\hat{\Theta}_{MSM} = \text{argmin } \tilde{g}(\Theta, \Phi) W_T \tilde{g}(\Theta, \Phi)$$

Where

$$\tilde{g}(\Theta, \Phi) = \begin{bmatrix} \frac{1}{N}\sum_{i=1}^{N}\{p_{it} - \tilde{p}_t^e(z_{it}, \Theta, \Phi)\} \\ \frac{1}{N}\sum_{i=1}^{N}\{\log h_{it|p_{it}>0} - \log \tilde{h}_{t|p_t>0}^e(z_{it}, \Theta, \Phi)\} \\ \frac{1}{N}\sum_{i=1}^{N}\{a_{it} - \tilde{a}_t^e(z_{it}, \Theta, \Phi)\} \end{bmatrix}$$
$$t = \{1, ..., T\},\ e \in \{non-college, college\}$$

W_T could be an optimal weighting matrix given by the inverse of a consistent estimate of the covariance matrix of data moments. However efficient choice of weighting matrix could introduce finite sample bias. Hence the following non-optimal weighting matrix is used for the structural estimation in this paper:

$$W_T = \left[diag\Big(var\big(\frac{1}{\sqrt{N}} \sum_{i=1}^{N} m_{it}\big)\Big)\right]^{-1}$$

Where m_{it} is a vector of data moments

6 Results

6.1 Estimation

Table 3 shows our structural parameter estimates. Our model is estimated on data for male household heads who are born between 1931-1935. The estimated discount factor is higher for married men as compared to singles and also for college graduates as compared to those without a college degree. It ranges between 0.97 to 1.0 where the lowest value is for singles without a college degree and highest corresponding to those who are married and have a college degree.[39] The coefficient of relative risk aversion ranges between 2.0 and 2.24 across individuals in these four permanent groups and the consumption weight between 0.45 and 0.51. Together these two parameters imply an inter-temporal elasticity of substitution for consumption $\frac{-1}{\nu(1-\rho)-1}$ which ranges between 0.69 and 0.62 for these four groups respectively. The intensity of bequest motive is estimated to be between 1.11 and 18.56. We allow the time cost parameters to vary by age, education and health. Both time cost of participation and being in bad health are relatively high at younger ages. For instance, our model estimates that the time cost of participation for those in excellent health ranges between 750 and 1200 annual hours at age 25 for the four groups (refer to appendix figure C.5). While the time cost of being in the worst health state is relatively high for all groups, it the highest for singles with a college degree. Empirically, college educated group is less likely to work at older ages in the event of a bad health shock than non-college group. The structural model rationalizes this observation in terms of differences in bad health time cost at older ages. Time endowment parameter $\bar{l}$, in terms of annual hours, is estimated to be between 5,925 and 5,064 for these groups.

6.2 Benchmark Model

Figures 6-8 show the benchmark model fit for average participation, hours worked and wealth over the life cycle for male household heads (born between 1931-1935) by marital status and education group. Our structural model performs well in matching these moments – especially for college graduates in both education groups.

We next check to see if the model is able to generate a reasonable prediction for moments that were not targeted explicitly in the structural estimation. We are particularly interested in seeing how the model performs in predicting the Social Security claiming behavior for our simulated cohort. Figure 9a shows the Social Security claiming behavior for all the simulated individuals in the model. We find that the estimated model generates substantial early claiming, however it some-

[39]Previous literature, including Becker and Mulligan (1997) and Doepke and Zilibotti (2008) has demonstrated that increasing education also increases the patience of individuals.

Table 3: Estimated Parameters

Parameter	Description	Singles		Married	
		Non-College	College	Non-College	College
β	discount factor	0.972	0.986	0.979	1.000
ρ	coefficient of relative risk aversion	2.006	2.113	2.227	2.240
ν	consumption weight	0.446	0.508	0.466	0.489
θ_{beq}	bequest weight	1.108	1.090	1.621	18.563
$\bar{l}$	time endowment	5925	5484	5912	5064

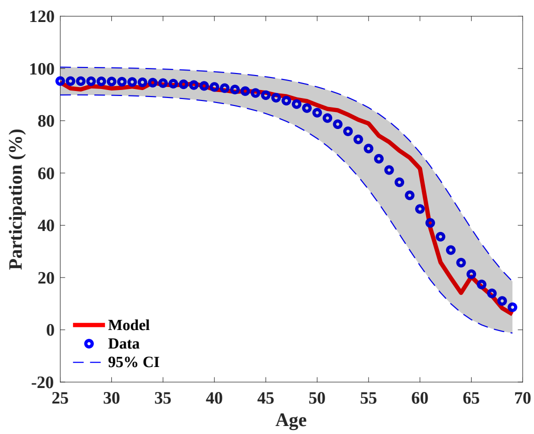
what under predicts claiming at age 62 and over predicts claiming after age 63. The benchmark model is not able to generate the small number of delayed claims (after age 65) as observed in the data.

Apart from matching the overall Social Security claiming behavior well, the model is also able to predict several important characteristics of early Social Security claimers (those claiming benefits before their normal retirement age). For instance, the model generates the strong correlation between retirement and early claims as observed in the data. First three rows of Table 5 show percent early claimers by labor force participation status at age 62. Specifically, 95.2% of men not working at age 62 were seen claiming early in the data, the model predicts this to be 91.2%. Similarly, the model closely matches the early claiming rates of those who were in excellent or fair health at age 62. However, it over predicts the early claiming rates of those in the worst health state. For permanent states like marriage and education, it generates a reasonable match for the early claiming behavior of college graduates (60.4 data vs. 65.9 model) and those who are married (66.9 data vs. 64.5 model) and substantially over predicts the early claiming rates of those without a college degree and singles.

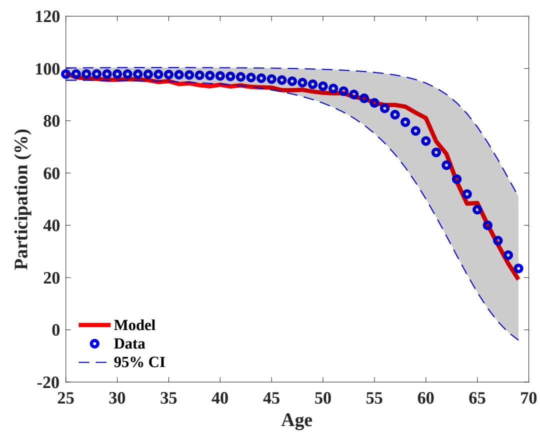
The benchmark model generates a gradient in early claiming by both AIME and non-Social Security wealth. Table 4 shows the percent of agents claiming Social Security benefits before their normal retirement age in each wealth quintile for both the data and the model. The model somewhat over predicts early claims for those in the lowest quintiles and under predicts for those in the highest quintile. Figure 9b shows the fraction of early claimers in each Social Security wealth quintile. The fraction of those claiming early goes down from over 84% in the lowest quintile to 61% in the highest quintile. There is also a strong correlation between Social Security and personal wealth. For instance, those in the highest AIME quintile have roughly four times higher wealth than those in the lowest quintile.

Figure 6: Benchmark: Participation by Education and Marriage
Men born in 1931-1935

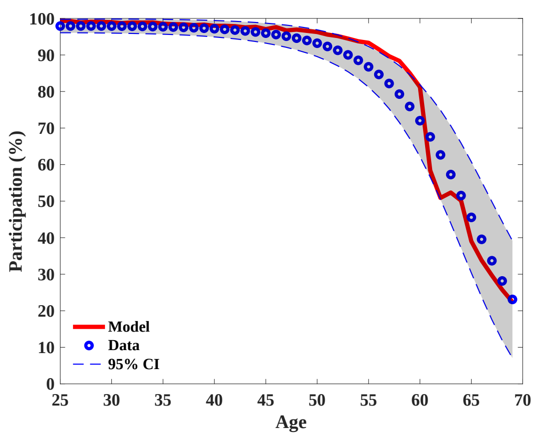
(a) Non-College, Non-Married



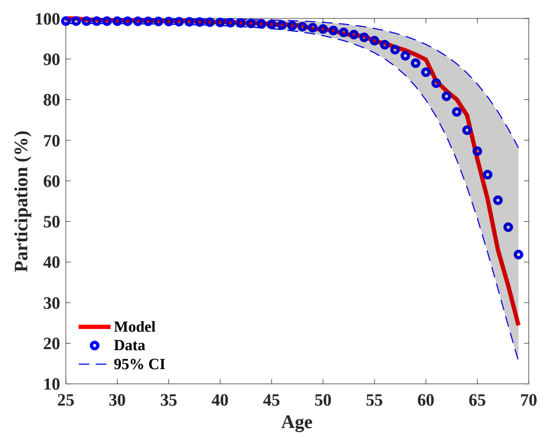
(b) College, Non-Married



(c) Non-College, Married



(d) College, Married



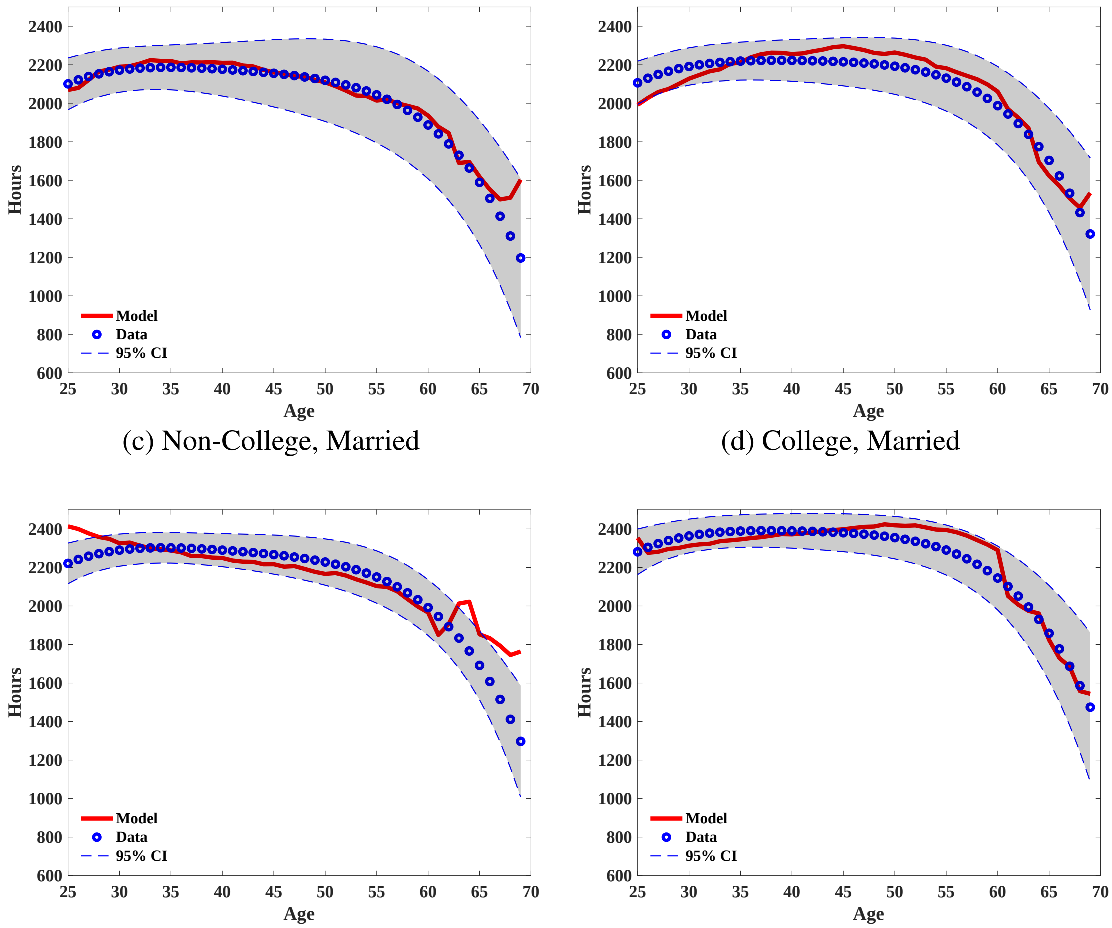
6.3 Model Validation

Even though we are not explicitly targeting the social security application moments in our structural model, part of the results could be driven by targeting the labor supply and wealth moments for our benchmark birth-cohort. In order to validate our benchmark model, we would like to test its predictions for the SS claiming behavior of a later birth cohort that experienced different Social Security Rules. Specifically, those born in 1941-1945 observed a normal retirement age of 66. This cohort also experienced only part of the earnings test as in the year 2000, it was removed for those 65 and older. At the same time, the later cohort experienced a higher delayed application credit of 8%. We feed these three important Social Security changes in the benchmark model while

Figure 7: Benchmark: Hours by Education and Marriage
Men born in 1931-1935

(a) Non-College, Non-Married (b) College, Non-Married

(c) Non-College, Married (d) College, Married

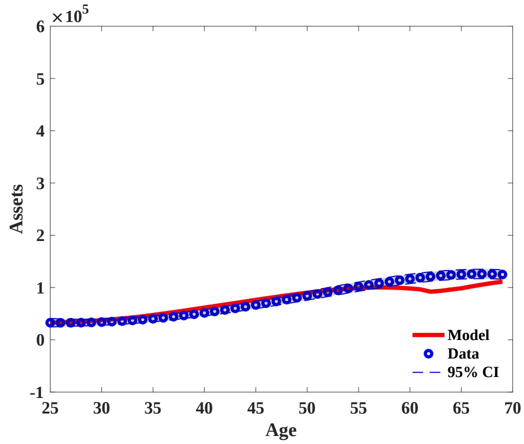


keeping all other parameters the same.

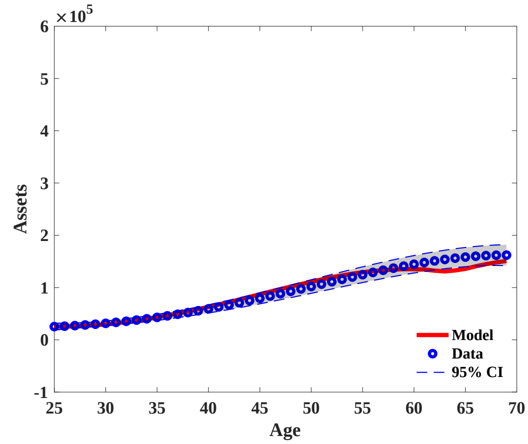
Figure 10a shows the cumulative SS claims for both our benchmark cohort and those born in 1941-1945 in the data and figure 10b shows the same in the model. The model is able to closely match three interesting features of the changes in social security claiming behavior observed across these two birth cohorts in the data. First, increasing in NRA and removal of earnings test past 65 did not have a big impact on age 62 claims. This illustrates the idea that perhaps most of these early claims are driven by behavioral or health channels. Second, these Social Security changes resulted in a roughly 7 percentage points (p.p) decline in claims at age 65 both in the model and the data. Finally, claiming after age 65 went up by roughly 13 p.p in the data and by 12 p.p in the model. The fact that our model is able to capture well these SS claiming features of the data for a later birth cohort, one that was not used in the estimation, gives us further confidence that it is well suited for understanding the drivers of social security claiming.

Figure 8: Benchmark: Wealth by Education and Marriage

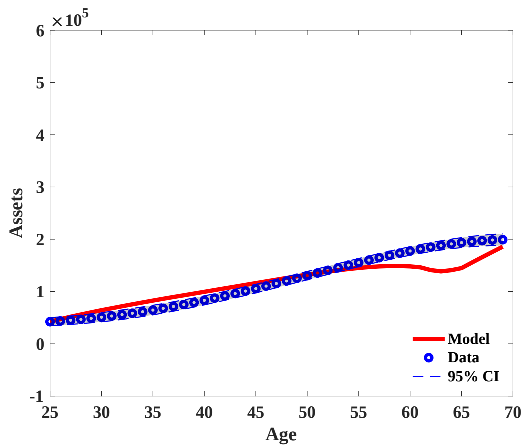
(a) Non-College, Non-Married



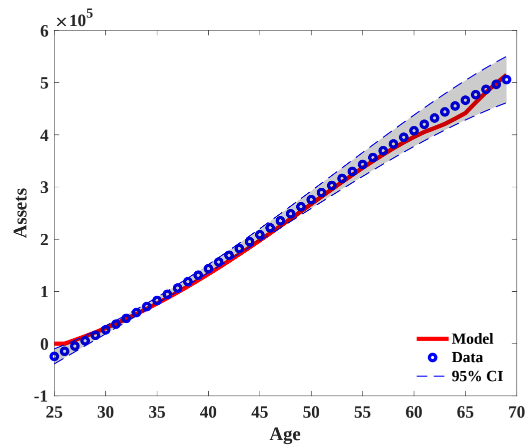
(b) College, Non-Married



(c) Non-College, Married



(d) College, Married



6.4 Counterfactual Experiments

In this section, we conduct experiments to understand the relative importance of each channel in explaining Social Security claiming behavior of men.

6.4.1 Unemployment Shocks

We first conduct an experiment where we switch off unemployment shocks for all individuals in the model. This will help us identify the precautionary motive channel driving early claiming behavior. In the model, switching off the unemployment shocks implies that unemployed individuals experience no wage-scarring effects if they choose to go back to work right away.

We find that unemployment shocks have a relatively small effect on the extensive margin of labor supply at younger ages, especially for college graduates, and somewhat larger effects later in the life-cycle. Appendix figure C.7 shows labor force participation for individuals by their

Figure 9: Benchmark: Social Security Claiming Behavior

(a) Cumulative SS Application

(b) Early Applications by AIME Quintile

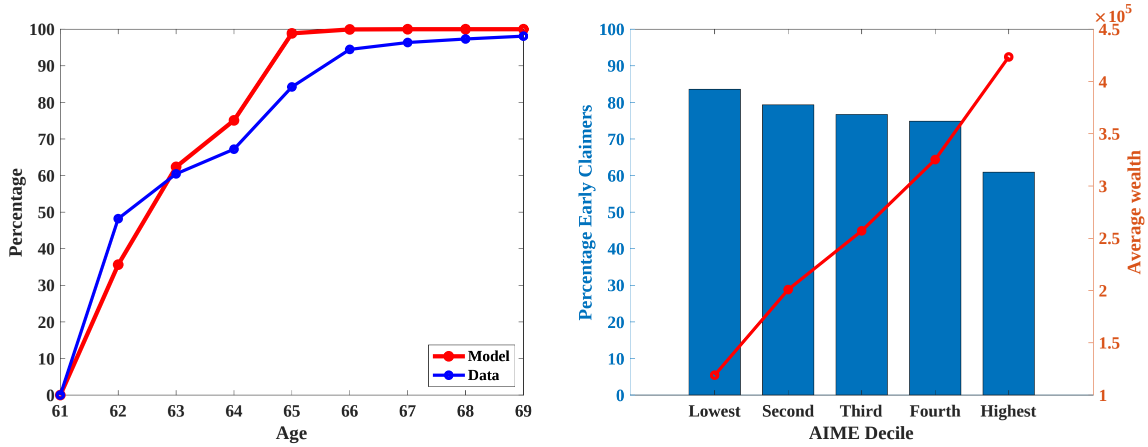


Table 4: Early Claiming by Wealth Quintiles

% Early Claimers	Lowest	Second	Third	Fourth	Highest
Model	94.2	88.9	80.7	61.9	49.7
Data	76.1	71.1	70.1	65.7	64.9

Notes: *Percent of those claiming before their normal retirement age is reported for each wealth quintile both in the data and the model. Data is for male household heads from the Health and Retirement Study.

education and marital status, both for the benchmark and the model without unemployment shocks. Average participation increases by 10 to 15 percentage points between ages 60 and 65. Steep Earnings Test for SS beneficiaries between ages 62 and 65, declining health, combined with wage scarring effects of unemployment spells make individuals' labor supply particularly sensitive to shocks at these ages. As a result, in the model without unemployment shocks, individuals stay in the labor market longer and claim SS benefits closer to their normal retirement age. This is demonstrated by the fact that claiming before the normal retirement age (65) goes down by 9.5 p.p (refer to table 6) and delayed claims go up by 2.5 p.p. (refer to appendix table C.2).

We find that along with the aforementioned effect, there is another important effect operating through the evolution of wages over the life-cycle. The scarring effect of unemployment on wages is substantial and simulated life-cycle wages without scarring are significantly higher for both education groups (refer to appendix figure C.6). As a result, Social Security wealth evolution over the life-cycle also differs significantly. For instance, at age 60, social security wealth is roughly 40% higher as compared to benchmark (refer to figure C.8). In a scenario where individuals hold overall higher personal (refer to figure C.9) and Social Security wealth, there is a shift away from

Table 5: Heterogeneities in Early Claiming

% early claimers	Data	Model
*Work Status**		
Not working	95.2	91.6
Working	55.7	65.2
*Health**		
Excellent	63.0	65.2
Fair	68.4	73.7
Poor	78.5	99.9
Education		
No College	73.5	87.9
College	60.4	65.9
Marital Status		
Singles	76.6	97.7
Married	65.2	64.5

Notes: *For health and labor supply, which are not fixed over the life-cycle, age 62 status is considered in both the data and the model to see it's impact on early claiming. Early claimers refer to those claiming before the NRA (age 65).

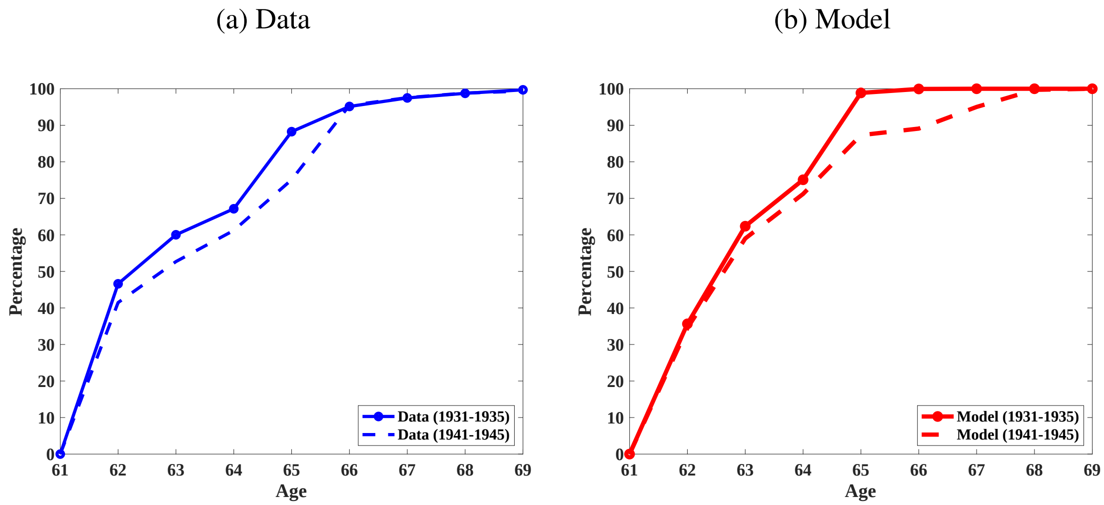
claiming early. This is particularly true for singles as early claiming rates go down by roughly 12 and 31 p.p for the no-college and college groups respectively among singles. Married individuals have valuable insurance through their spouse's income in the event of unemployment spells and as a result their early claiming decisions are relatively less sensitive to these shocks. While early claiming rates for married college graduates go down by 7 p.p, their delayed claiming rates go up by 5.6 p.p. This demonstrates that while unemployment shocks may have a relatively smaller effect on the early claiming behavior of this group (as compared to the single college graduates), it does have an important effect on decisions to delay SS applications. For the non-college married group, elimination of unemployment shocks has a negligible, albeit positive, effect on early claims.

6.4.2 Health Shocks

We next conduct an experiment where we switch off the effect of bad health on time endowment, labor productivity and spousal income for all individuals in the model.[40] Changes in life expectancy have a distinct effect on early claiming, so in order to disentangle that channel from other wage effects, we keep life expectancy the same as benchmark. In other words, we still allow for the bottom two health states to affect survival probabilities.

[40]In our model solution, individuals with the bottom two health states observe wages, time endowment and spousal income of those in excellent health (within their age-education group)

Figure 10: Model Validation: SS Claiming Behavior of 1941-45 Birth Cohort



We find that bad health shocks, without their mortality impacts, have a relatively small effect on early claiming behavior. As shown in table 6 (third row), early claiming rates go down by only 0.5 p.p. where most of this effect is coming from single non-college group.

We find significant effects of this experiment on the extensive margins of labor supply at younger ages, especially for the singles, as well as close to retirement years (with the exception of married college graduates). Bad health affects lifecycle earnings through both hours worked and its effect on hourly wages. As a result, Social Security wealth evolution over the life-cycle also differs somewhat. For instance, at age 60, social security wealth is roughly 7% higher as compared to benchmark. In a scenario where individuals hold overall higher personal and Social Security wealth, there is a shift away from claiming early for most individuals, with the exception of the married non-college group which experiences a negligible albeit positive effect on early claims.

6.4.3 No Bequest Motive

We next explore the importance of bequest motive in generating early Social Security claiming. We do this by setting the end of life flow utility to zero for all individuals. Note that for married individuals, we still allow end of life utility from bequeathing their Social Security benefits to their spouses as survivor's benefits. As Social Security benefits are not bequeathable otherwise, individuals may want to maximize the amount of their bequeathable wealth by applying early and accumulating the cash flows over a longer period of time. This channel may be particularly important for those who are facing bad health shocks and lower longevity.

Table 6 (seventh row) shows that this is indeed the case. Removal of bequest motive results in a 14 p.p reduction in overall early claims. At the same time, there is a roughly 9 p.p increase in

Table 6: Counterfactual Experiments
Changes in Early SS Claiming

Experiment	All	Singles		Married	
		Non-College	College	Non-College	College
Precautionary	-11.8	-22.8	-34.4	0.3	-6.6
Unemployment	-9.5	-12.1	-31.2	0.6	-7.0
Health	-0.5	-1.1	-0.3	0.2	-0.7
Misinformation	-14.9	-0.3	-10.7	-5.2	-27.5
Mortality	-10.1	0.1	-9.3	0.4	-20.3
SS Program	-3.7	-0.4	-0.3	-5.8	-4.9
Bequest	-14.1	-2.7	-53.4	10.0	-19.1
Discount Rate	-1.4	0.4	-1.1	-5.4	-

Notes: for each experiment, percentage point change in early claiming (claims before age 65) as compared to benchmark is reported for each sub-group as well as all individuals in the simulated sample.

delayed claims (refer to appendix figure C.2). We also find a significant heterogeneity in changes in the claiming behavior, in response to this experiment, across different marital and education groups. While the married non-college group experiences a 10 p.p *increase* in early claims, the college singles observe a drastic 53 p.p reduction in their early claims. At the same, almost the entire increase in delayed claims is due to the married college educated group.

The bequest channel works in the aforementioned way for the college group, where accumulating a larger buffer stock of social security benefits now does not amount to higher end of life utility. As a result, for both married and non-married individuals in this education group, there is substantial decline in their early claims (for both groups, almost half of their early claims goes down). For the non-college group however, there is another countervailing mechanism at play. In the absence of bequest motive, the model does not generate the growth in personal wealth as seen in older ages (see figure C.9). This is particularly true for the non-college group that completely draws down their assets close to retirement years and become largely dependent on their Social Security benefits to fund post-retirement consumption.[41] This motivates them to claim earlier rather than later. This is especially important for the married group as they also enjoy spousal benefits in addition to their own upon claiming. As a result, the married non-college group experiences an overall *increase* in their early claims and sharp declines in labor supply starting age 65 (refer to appendix figure C.7) as compared to the benchmark. The singles do not have additional income that married individuals enjoy through spousal benefits. As a results, they stay in the labor market

[41] Note that the estimated discount factor is relatively smaller for the two non-college groups and the growth in their life-cycle wealth in the benchmark model is mostly attributable to the bequest motive.

Table 7: Prob(live to 75 | alive at 62)

	Self Report	Realized
Non College, Single	0.57	0.55
Non College, Married	0.63	0.62
College, Single	0.61	0.70
College, Married	0.70	0.82

Notes: Realized probabilities are constructed from estimated survival probabilities, from the Health and Retirement Study data, which are based on observed age at death for each respondent.

relatively longer and somewhat delay their claims to the normal retirement age.

6.4.4 No Mortality Misinformation

Individuals may under/over estimate their chances of survival which can have a direct impact on their claiming behavior. In the health and Retirement Study data, individuals are asked to report their subjective chance of survival to various ages like 75, 85 and so on (refer to the appendix table C.1). At the same time, their true survival chances can also be estimated from the same dataset based on the actual age of death. This gives us a way to understand the nature of bias in their subjective evaluation of their own mortality. Table 7 reports both the self-reported and actual probabilities of survival to age 75, conditional on being alive at age 62, for each education and marital group. We find that in general non-college graduates slightly over predict their chance of survival. However, the college graduates in both marital groups under-predict their chances of survival by roughly 10 percentage points.

In order to understand the impact of this misinformation on Social Security claiming behavior, we conduct an experiment where we give individuals their true survival probabilities, instead of the ones based on their subjective evaluations. We find that correcting for mortality misinformation results in a roughly 10 percentage points decline in early claiming (refer to table 6). The largest effects come from the college educated group. There is also a roughly 9 percentage points increase in delayed claims (refer to appendix table C.2), coming solely from the married college educated group. Given the longer life-span, this group delays their exit from the labor market (refer to appendix figure C.16) as well as their Social Security benefit claims.

6.4.5 SS Program Knowledge

Next, we explore the importance of the knowledge about the early application penalty in generating early claiming behavior. For this, we allow all our simulated individuals to be perfectly informed about the early/late SS application penalty/credit. Figure C.19 shows that this does not have any impact on the labor supply margin on any of the education-marital groups. In fact, other life cycle profiles like wealth, hours worked and evolution of social security wealth remain almost identical to the benchmark. This shows that the informed and uninformed individuals behave in the same way regarding their labor supply and savings decisions. However, the Social Security claiming behavior is significantly different. There is 3.7 percentage points decline in overall early claims where most of this change is driven my married individuals, especially those who are college educated. This indicates that misinformation about Social Security rules by itself only impacts the claiming behavior of individuals who have additional insurance through their spouses and higher earnings. In the absence of valuable spousal insurance, the claiming behavior of singles is largely driven by other precautionary channels.

Misinformation about early application penalty however has very small effects on claims past age 65. There is only a 0.11 p.p increase in delayed claims, the effect coming solely from the married college educated group.

6.4.6 Discount Rate

The structural model developed in this paper uses the differences in the evolution of life-cycle labor supply and wealth across different education-marital groups, given all observables , to identify heterogeneity in preference parameters. Of particular importance is the discount factor (β) which has a direct impact on when individuals choose to claim. The model estimated discount factor varies significantly across the four groups with non-college singles having the lowest value (0.972) and college graduates having a discount factor of almost 1.0. In order to understand the relative importance of discount factor in explaining early claiming behavior, we conduct an experiment where we give the same discount factor (1.0) to each group. This of course leaves the behavior of the married college group unchanged but affects the patience level of other groups by varying degrees.

Table 6 (8^{th} row) shows that changes in the discount factor by itself has a relatively small effect on overall Social Security early claims (decline by 1.4 percentage points) and almost no effect on delayed claims. Most of the decline in early claims is coming from the married non-college graduates as we observe a 5.4 percentage points decline in early claims for this group followed by the single college graduates (1.1 p.p decline). There is a negligible albeit positive effect on the early claims of the single non-college group. This group experiences the most drastic increase in their discount factor (0.972 to 1.0). As a result, they quickly build up wealth early in the life-cycle by delaying both consumption and leisure (labor supply does up by 4-5 p.p for this group between ages 25 and 40 and consumption declines by 10 to 20%). This group then also experiences a much faster exit from the labor market (labor force participation at age 60 declines by roughly 35 p.p) around the time when bad health shocks become more prevalent. Early exits from the labor market reduces the relative attractiveness of delaying SS claims from the time they first become available.

As a result, the two effects almost cancel out for this group and we see little impact of changes in discount factor on their SS claiming behavior.

7 Conclusion

This work revisits the retirement and social security claiming decisions by incorporating new sources of heterogeneity and mechanisms governing these decisions in a structural life-cycle model. We first document some empirical facts related to early claiming from the Health and Retirement Study data: nearly 50 percent of workers choose to claim at the earliest age of eligibility, there is a link between labor force participation and early claiming, non-married individuals without a college degree and those in poor health are more likely to claim early, and there is substantial misinformation among individuals related to SS program rules and their survival chances at older ages. We build a life-cycle model of consumption, savings, retirement and Social Security claiming, which is informed by these facts, to study the joint retirement and claiming decisions. The model is estimated using the Method of Simulated moments, targeting moments related to labor supply and wealth evolution over the life-cycle. We show that our estimated model closely matches the claiming behavior of the cohort of men born between 1931-35 and is consistent with the empirical facts we document, even though these Social Security moments were not targeted during estimation. Finally, we run counterfactual experiments to disentangle the forces at play in the model. We find that precautionary motive, misinformation, and preferences governing future discounting as well as altruism, together, go a long way in explaining overall claiming behavior. Together, these forces can explain a third of the overall early benefit claims. However decisions to delay claims remain largely governed by life expectancy considerations. We also find substantial heterogeneity in the strength of each channel in explaining the claiming behavior of different education and marital groups.

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Appendix

A Data: PSID, HRS, MEPS, and UAS

The Panel Study of Income Dynamics (PSID) is used to estimates life-cycle profiles of labor force participation, hours, and wealth; the wage process; and the initial conditions. PSID is a national representative longitudinal survey in the United States. The original PSID sample was drawn from the nationally representative SRC sample and an oversample of the low-income SEO sample.

We use the a sample of individual from the SRC sample who were interviewed twice or more between 1968 and 2017. Out sample consists of only male household heads between the ages of 20 and 70 who were born between 1926 and 1970. Our final sample consists of 84,532 observations. When we consider the wealth profiles, we consider workers up to age 80. This sample consists of 86,540 observations.

The Health and Retirement Study (HRS) is a longitudinal study of Americans over the age of 50. Version O is used in this work. Importantly, the survey contains questions related to retirement and Social Security claiming decisions. The sample used covers workers within the HRS cohort; this cohort contains workers born between 1931 and 1941.[42] This work focuses on a sample of 86,823 male workers.

We use the Household Component of Medical Expenditure Panel Survey (MEPS-HC) to identify health and mortality related parameters. MEPS-HC is a nationally representative survey of the U.S. civilian noninstitutionalized population. The sampling frame is drawn from respondents to the National Health Interview Survey (NHIS), which is conducted by the National Center for Health Statistics.

The Understanding America Survey (UAS) is used to study what percentage of workers understanding the Social Security rule and the penalty associated with early benefit claims. UAS is a panel dataset of roughly 9,000 respondent representing the United States. The panel is an internet study where respondent can respond digitally whenever they choose. We use a sample of 5,388 observations in this work. This dataset is used to measure the degree to which individuals understand the Social Security system.

B Estimation Details

B.1 Wages

Wage data is used in the calculation of the intial conditions as well as in the estimation of the wage profiles and shocks. Data on wage is taken from PSID. In PSID, the hourly wage is calculated as annual earnings divided the annual hours worked. In order to perform this estimation, we proceed in three steps described below.

Step 1 Impute potential wages for missing observations

[42] There are other cohorts contained with HRS. This cohort is used as we can see the full information related to retirement decisions

For obvious reasons, we only observe wages for those workers who participate in the labor market. In order to deal with this we impute a potential wages, $\ln \hat{w}_{it}$, for those workers who have a missing wage.

First, we run the regression in 19 to estimate how the wage varies based upon characteristics. The dependent variable is the natural log of the hourly wage for individual i in year t. γ_i is an individual fixed effect and X'_{it} is a set of explanatory variables including a fifth-order polynomial in age, education level, and self-reported health status. We estimate the regression including interaction terms between these explanatory variables.

$$\ln w_{it} = X'_{it}\beta + \gamma_i + \varepsilon_{it} \tag{19}$$

Using the results from Equation 19, we impute the wage for those workers with a missing observation. Specifically, the potential wage, $\ln \hat{w}_{it}$, is constructed as shown in 20. The data observation for the wage is used for those workers with a wage. In this value is missing, the potential wage is imputed using the estimated parameter values from Equation 19.

$$\ln \hat{w}_{it} = \begin{cases} \ln w_{it} & \text{if } w_{it} \neq . \\ X'_{it}\hat{\beta} + \hat{\gamma}_i & \text{if } w_{it} = . \end{cases} \tag{20}$$

The advantage of the procedure above is allowing us to deal with issues of selection related to who participates in the labor market and receives a wage. However, this method also requires an assumption that the choice of participation is not driven by wage offers that are correlated with these expanatory variables. For example, we must assume that the participation decision of workers who report low self-reported health are not driven by being offered lower wages than their healthy peers of the same education level.

Given that we now have wage observations for our sample, the wage profiles can be estimated from the wage data.

Step 2 Estimate wage profiles $\omega^e(j, m)$, as a function of age, education, and self-reported health status

The wage profiles are estimated using the regression in Equation 21 where f_i is an indvidual-specific fixed effect and $g_{e,m}(t)$ is an education and self-reported health specific polynomial in age.

$$\ln \hat{w}_{it} = f_i + g_{e,m}(t) + u_{it} \tag{21}$$

Note that we do not control for birth-year cohort in this wage estimation. Because birth-year cohort is fixed throughout a worker's life, the impact of this, as well as other time invariant characteristics are absorbed into the fixed effect.

Step 3 Estimate the persistence, ρ, and variance, σ^2_ε, of the stochastic portion of the wage

The persistence and variance of the AR(1) process for the stochastic wage shocks are estimated by minimum distance estimation using the identity matrix as weighting matrix.

B.2 Wealth

PSID gather information on family wealth in 1984, 1989, 1994, and biannually from 1999 to 2019. The measure of wealth used includes home equity, farm/ business value, checking and savings wealth, value of other real estate, stocks, vehicles, and other assets net any debts.

We impute potential wealth for the years that observations are missing using a fixed effect regression.

$$\ln\left(W_{it}+\delta\right)=x_{it}'\beta+\gamma_i+\varepsilon_{it} \tag{22}$$

where δ is a shifter that is set equal to the minimum value of wealth in the sample to ensure that logs are taken of only positive values and W_{it} is te wealth of individual i at age t. x_{it}' is a set of controls which includes a quadratic polynomial in age, fully interacted with a dummy for education level and self-reported health status.[43] Additionally, γ_i is an individual fixed effect. This regression equation is estimated separately for single men, single women, and married individual. Then,

$$\hat{W}_{it}=\begin{cases}W_{it} & \text{if } W_{it}\neq .\\ \exp\left(x_{it}'\hat{\beta}+\hat{\gamma}_i\right)-\delta & \text{if } W_{it}= .\end{cases} \tag{23}$$

Wealth is used to construct the lifetime wealth profiles. These profiles are constructed for a sample of male household heads born between 1926 and 1990 and between the ages of 20 and 84. Additionally, we drop individuals with negative wealth.

B.3 Spousal Income

We include spousal income in the budget constraint of the married worker since we model only male household heads. Because of the high fraction of married household heads, the estimation of spousal income is important to understand the budget constraints faced by individuals. We first estimate how spousal income varies based upon characteristics of the head of houshold:

$$y_{it}^s=X_{it}'\beta+\varepsilon_{it} \tag{24}$$

where X_{it}' is a vector of control variables including a fouth order polynomial in the age of the household head, health of the household head (in both levels and interacted with the age polynomial), college of the head, and the labor income of the household head. We then use the estimated coefficients to impute spousal income in the model.

$$\hat{y}_{it}^s=X_{it}'\hat{\beta} \tag{25}$$

By estimating how spousal income varies based on characteristics of the household head, we capture impact of assortative matching and differing probabilities of marriage across education levels and health status.

[43] Self-reported health status is available only after 1984. For observations prior to 1984, the regression equation does not include a contol for health.

B.4 Kids and Marriage

Related to the spousal income estimation above, family structure differs across education types. Figure B.2a shows how marital status varies by both education and age. There are a few notable features. First, the fraction of individuals who are married is high and remains high throughout a worker's life-cycle with roughly 80 percent of workers married (or in a co-habitating relationship) at all points in the life-cycle. Second, the shar eof workers married increase sharply between ages 25 and 30. At age 25, around 70 percent of workers are married while this fraction is 80 percent by around age 30. College educated workers are slightly more likely to be married. However, the gap is small.

Figure B.2b shows how the number of children living in the household varies across the life-cycle and by education level and marital status. This neasures all children age 17 and under who are in the household at any point in time. Once again, there are a few notable features in this profile. First, the number of children is hump-shaped over the life-cycle. The number of children peaks between the ages of 30 and 40 and has declined to 0 by age 60. Second, the profiles differ for those with a college education and those without as well as between those who are married and single. Single workers have fewer children. Those without a college degree have more children early in their life cycle and their number of kids peaks at around 1.8 around age 35. College graduates, on the other hand, have fewer children early in life. The number of children in a college educated household peaks at slightly under 2 children at nearly age 40.

B.5 Age Gap between Spouses

Married couples have access to spousal benefits through the Social Security system; these benefits depend not only on the age of the worker but also on the age of the spouse. Therefore, the gap between the ages of the spouses is very important. Figure B.1 shows the distribution of this age gap for married couples born between 1926 and 1940. The average gap for this group is roughly 4 years.

The distribution shows 95 percent of the married couples have a positive age gap – meaning the male head is often older than their spouse. Additionally, 57 percent of these couples have age gaps between 0 and 4 years.

B.6 Taxes

PSID includes information on taxes paid up until 1991 and cover tax years up through 1990. In order to have individuals throughout the life-cycle, we extend the sample to those workers between the ages of 1916 and 1945. In order to estimate the parameters of the taxation function, we regress the natural log of total family income net of income on a constant and the natural log of family pre-tax income for each education level and marital status. Total taxable income of the family is measured as the sum of labor and Social Security income of the household head and the spouse and other family members (if present). Federal tax liability is constructed based upon the taxable income of the family as well as exemptions and the tax table used.

In order to maximize the sample size for measurement at each education level and marital status, we focus on estimating these parameters independently from age. The estimated parameters are shown in Table B.1.

Table B.1: Parameters of the Tax Function

	λ	ξ
No College		
single	1.35	0.041
married	1.32	0.043
College		
single	1.36	0.040
married	1.35	0.043

B.7 Misunderstanding of Social Security Rules

Given the complicated nature of the United States Social Security system, we allow an individual's claiming decision to, possibly, be impacted by whether or not they know about the system. Figure B.3 shows two measures of misunderstanding which are measured from the Understanding America Study; Figure B.3a show the fraction of workers, by education level, who believe there is no penalty for claims before the normal retirement age and Figure B.3b shows the fraction of workers, by education level, who effectively believe retirement and claiming are the same.

Both measures indicate that those individuals without a college degree are more likely to misunderstand the system. At age 25, roughly 20 percent of those without a college degree believe there is no penalty while only 10 percent of those with a college degree believe there is no penalty. These fractions are around 30 percent and 20 percent for those non-college and college educated workers, respectively, who believe retirement and claiming are the same decision. Additionally, this fraction which misunderstands–according to either method–is slightly decreasing over the life-cycle with younger workers having higher rates of misunderstanding. By age 62, the early retirement age, nearly 15 percent of non-college grades and 5 percent of college grads believe there is no penalty. For those who believe they cannot continue to work after claiming, between 10 and 15 percent of both college and non-college graduates misunderstand the system at age 62.

C Additional Details on Empirical Facts

C.1 Claims at the Early Retirement Age

In Section 2, we define early claiming at any claims prior to age 65, the normal retirment age for the cohort born between 1931 and 1935. Many workers, however, claim immediately when they become eligible at age 62. Therefore, Figures C.1 and C.2 show the results of Equation 1 where the dependent variable is an indicator for whether the worked claimed Social Security benefits at age 62.

Figure C.1 shows how age 62 claims are impacted by work status. The results show, similar to the case of all early claims, that work status significantly impacts at 62 claims with those workers who are not working at claiming age and at various lags are more likely to claim Social Security benefits that those who continue to work. Contrary to the case of early claims where work status in the year of claiming has the largest impact, for age 62 claims, work status 1 to 2 years prior to claiming has the most significant impact.

Figure C.2 shows how age 62 claims vary by education level and health status. With respect to education level, we document that those workers who do not have a college degree are more likely to claim Social Security benefits at age 62. However, with respect to self-reported health status, we find that the impact of health does not significantly impact whether a worker claims at age 62.

C.2 Impact of Occupation on Early Claiming

In most of the work, we document differences in early claiming behavior based upon education level. It is possible, however, that occupation is an important margin to consider. Figure C.3 shows how the probability of claiming prior to the normal retirement age varies by occupation. There is notable variation in early claiming probabilities across occupations. Specifically, occupations seems to fall into two groups: (1) those with a roughly 50 - 60 percent probability of claiming prior to the normal retirement, age and (2) those with roughly a 70 percent probability of claiming Social Security benefits early. The first group includes occupations such as management; business and financial; computer and math; architecture and engineering; life, physical, and social sciences; community and social services; legal; education; entertainment; and health practitioners. The second group includes health support; protective service; food preparation and service; building management and maintenance; personal service; sales; office and administration; farming; construction; maintenance; production; and transportation.

There is a strong correlation between these occupational groups and education level. Specifically, those occupations in the first groups (with lower probability of early claiming) are much more likely to have a college education. The share of those workers in these occupations with lower levels of claiming who have a college degree is 76 percent. This share is 32 percent for those occupations with higher probability of claiming early. Figure C.4 shows a more detailed breakdown on how the share of college graduates varies by occupation. The two groups mentioned prior are clear in this figure.

C.3 Misinformation about Life Expectancy

We estimate the parameters related to death from MEPS, but the model assumes that individuals know these probabilities. It is possible that there is misunderstanding related to how long an individual will live. This may impact the choice of claiming. In order to look into this further, we use a question in HRS which asks respondents what probability they believe they have of living to age 75 or age 85. We then compare these probabilities to what fraction of individuals actually live to this age. This is not an ideal comparison, but we use it to get an idea of how individuals view their own longevity. These comparisons are shown in Table C.1.

Results show that workers likely overestimate their mortality (or underestimate their longevity). Among workers who live to age 62, individuals–on average–believe they have a 65 percent chance of living to age 75 and a 41 percent change of living to age 85. These probabilities are lower for non-college educated workers (62 percent and 39 percent, respectively) and slightly higher for college graduates (69 percent and 44 percent). Comparing these probabilities to what fraction of

Table C.1: Expectations of Longevity

	Conditional on living to age 62, what is the probability you will...	
	live to age 75?	live to age 85?
Overall	65.1	40.8
No College	62.2	38.7
single	57.3	35.3
married	63.3	39.4
College	68.7	43.6
single	60.7	37.3
married	70.4	44.8

workers over age 62 live to these ages indicate that individuals are, perhaps, pessimistic about survival as roughly 90 percent of individuals live to age 75 and almost 80 percent live to age 85. Similarly, a slightly lower percentage of non-college graduates over 62 live to ages 75 and 85 while a slightly higher percentage of college graduates live to ages 75 and 85.

Table C.2: Counterfactual Experiments
Delayed Claiming

Experiment	All	Singles		Married	
		Non-College	College	Non-College	College
Precautionary	0.58	-0.04	0.00	-0.00	1.35
Unemployment	2.52	0.34	0.07	-0.00	5.61
Health	-0.43	-0.02	0.00	-0.00	-0.98
Misinformation	10.24	-0.00	0.00	-0.00	23.43
Mortality	9.16	0.00	0.00	-0.00	20.97
SS Program	0.11	0.00	0.00	-0.00	0.26
Bequest	8.65	-0.02	0.00	0.00	19.80
Discount Rate	-0.0	-0.0	0.0	-0.0	-

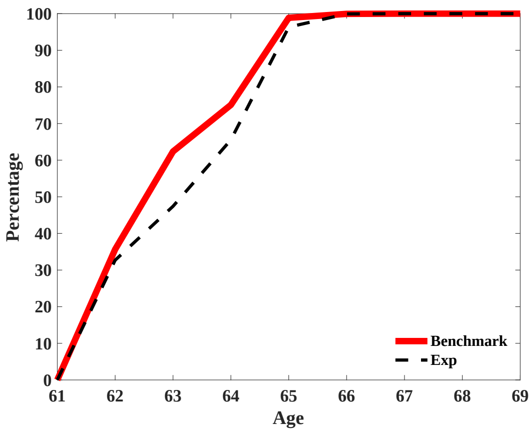
Notes: for each experiment, percentage point change in delayed claiming (claims after age 65) as compared to benchmark is reported for each sub-group as well as all individuals in the simulated sample.

Table C.3: Normal Retirement Age (NRA) by Birth Cohort

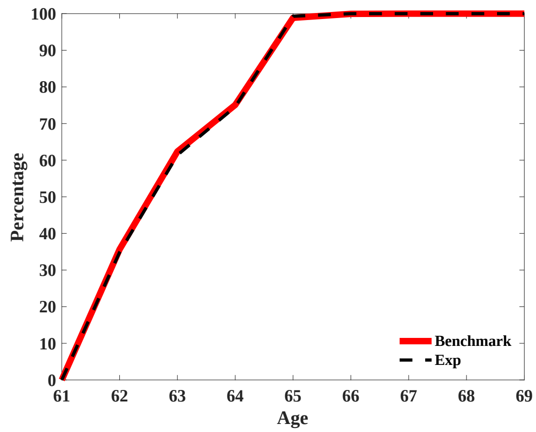
Year of Birth	Normal Retirement Age
1937 and prior	65
1938	65 and 2 months
1939	65 and 4 months
1940	65 and 6 months
1941	65 and 8 months
1942	65 and 10 months
1943-1954	66
1955	66 and 2 months
1956	66 and 4 months
1957	66 and 6 months
1958	66 and 8 months
1959	66 and 10 months
1960 and later	67

Figure 11: Counterfactual Experiments

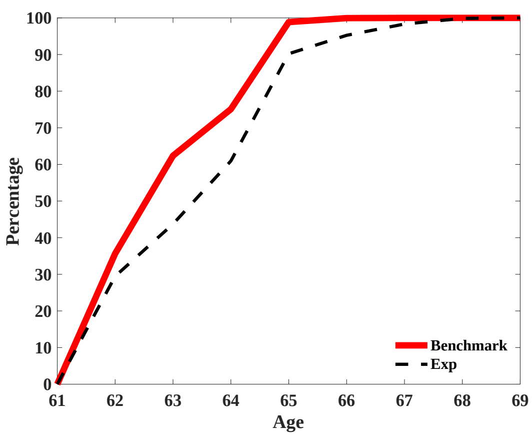
(a) No Unemployment Shocks



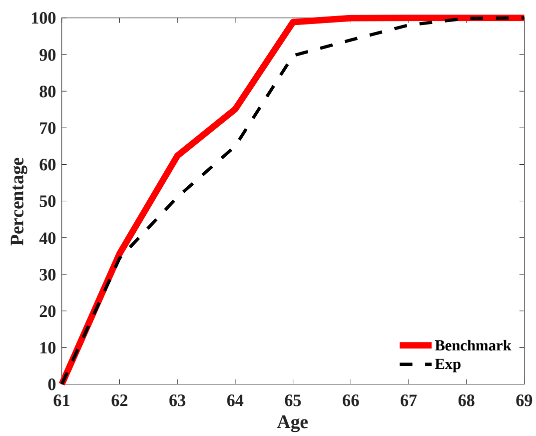
(b) No Health Shocks



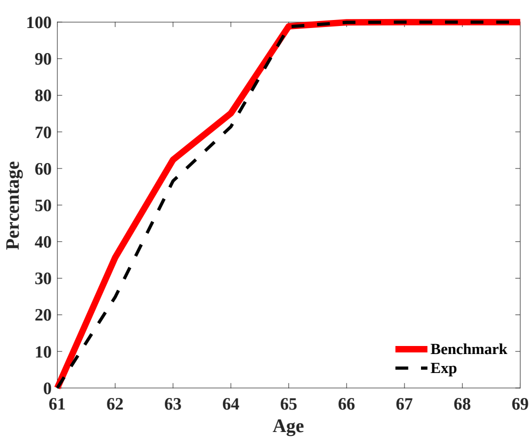
(c) No Bequest Motive



(d) No Mortality Misinformation



(e) No SS Program Misinformation



(f) Discount rate

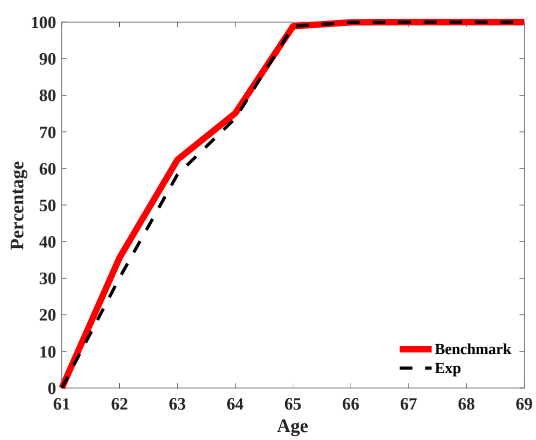


Figure B.1: Distribution of Age Gap between Spouses

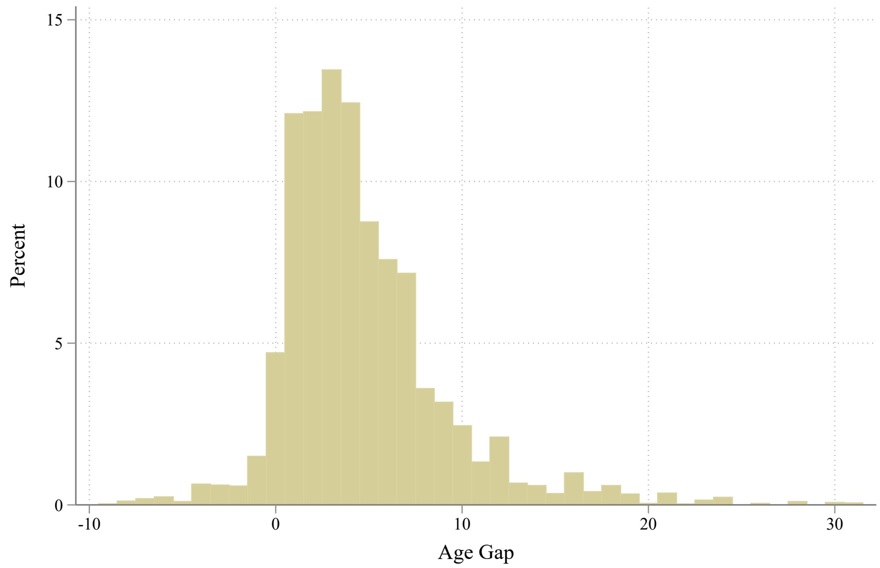
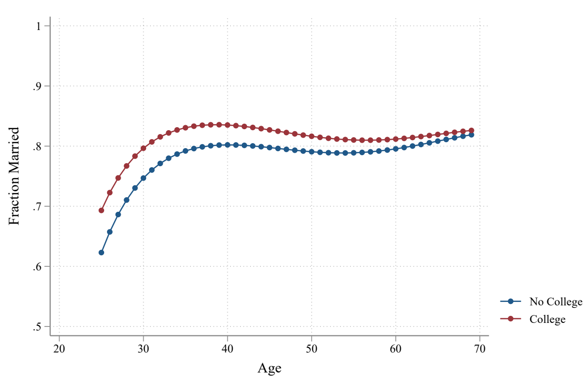


Figure B.2: Family Structure by Age, Education

(a) Marital Status by Age, Education



(b) Children by Age, Education

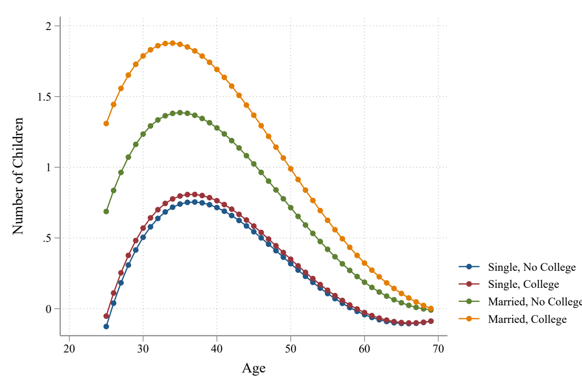
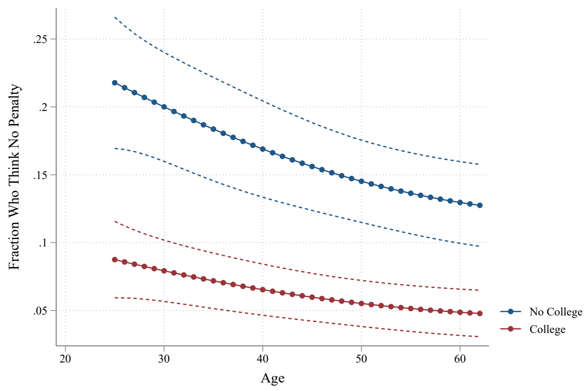


Figure B.3: Misunderstanding Over the Life-Cycle

(a) Believe No Penalty



(b) Believe Retirement and Claiming Decisions are Same

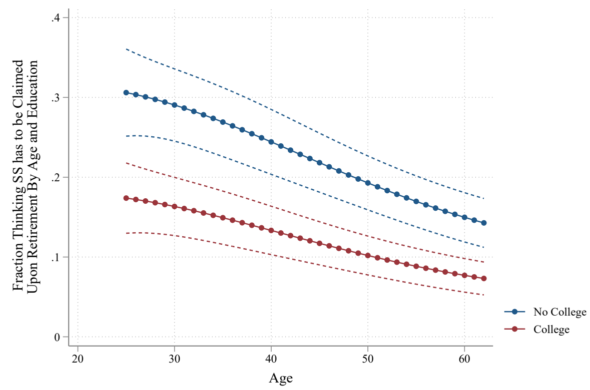


Figure C.1: Probability of Claiming at Age 62 by Work Status

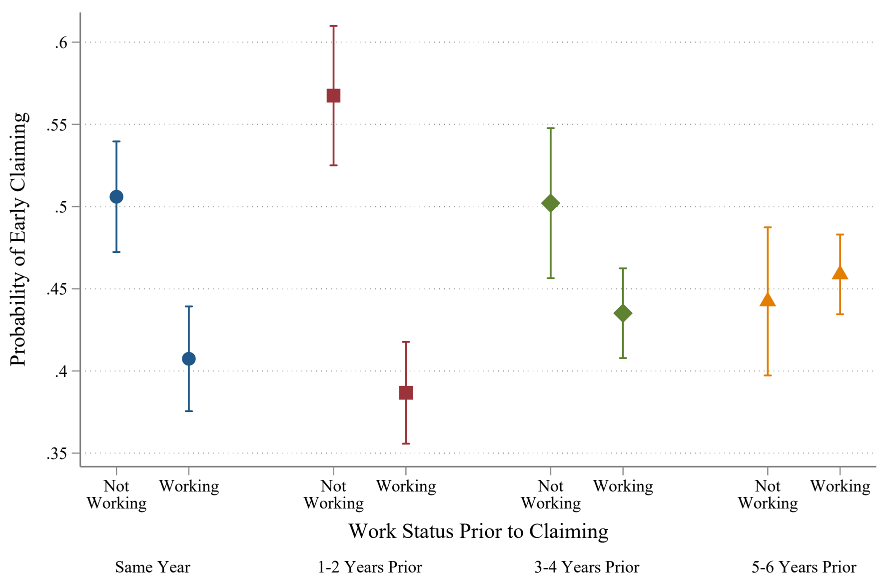


Figure C.2: Probability of Claiming at Age 62 by Education and Health

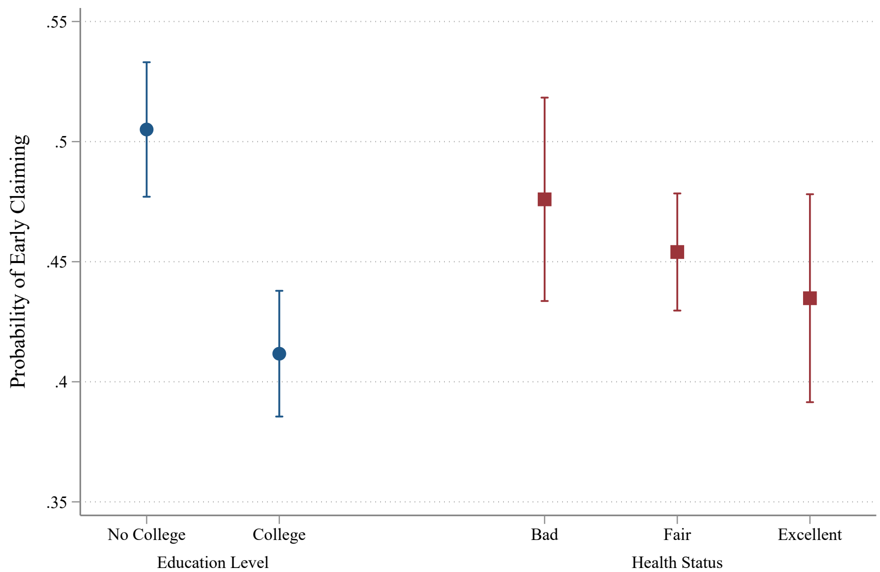


Figure C.3: Probability of Early Claiming by Occupation

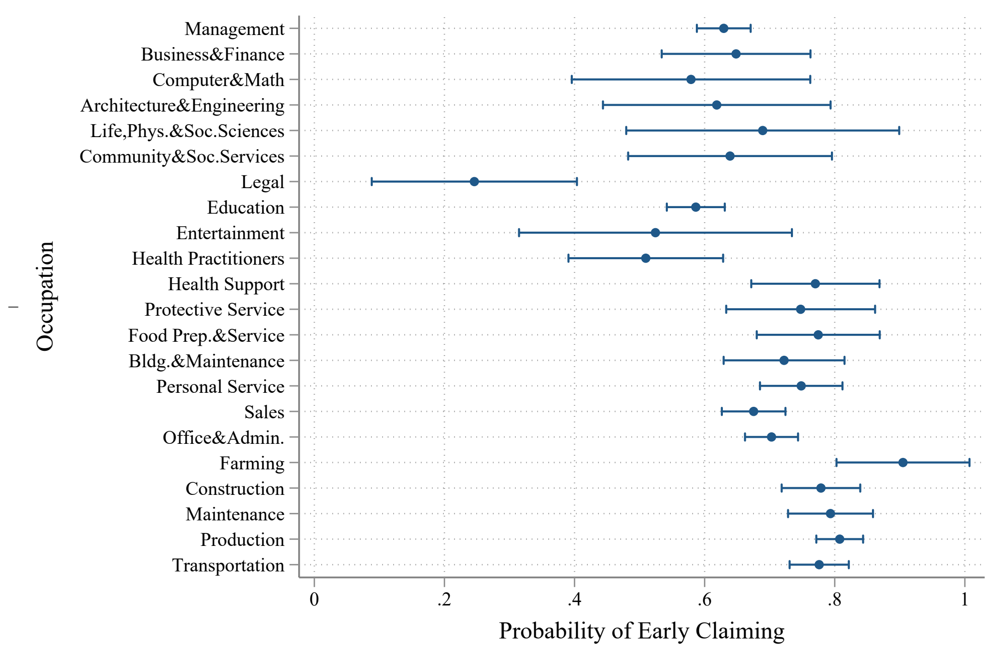


Figure C.4: Share of Workers with a College Education by Occupation

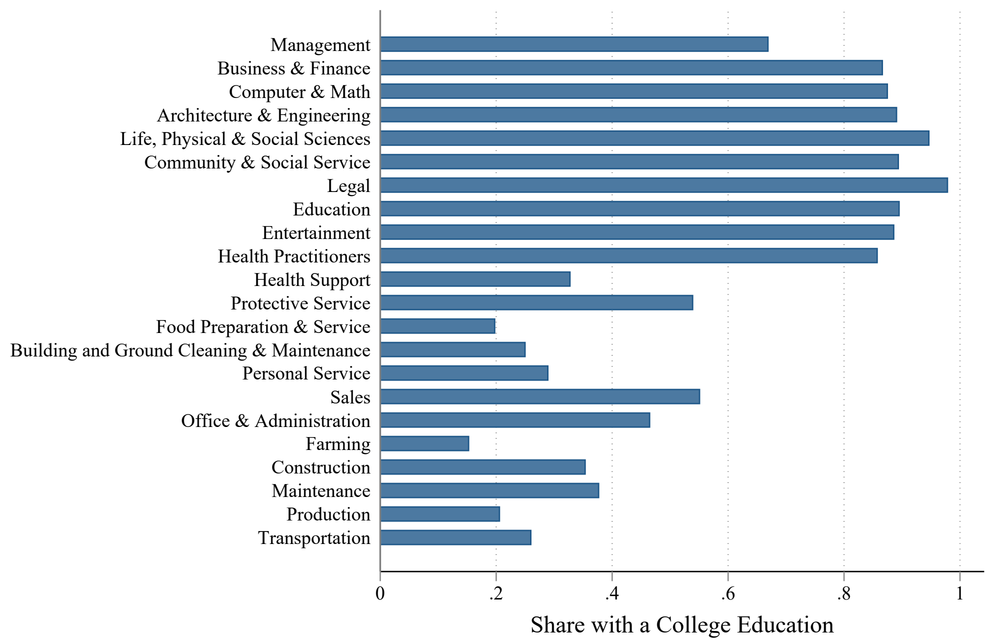


Figure C.5: Time Cost of Working

(a) Non-College, Singles

(b) College, Singles

(c) Non-College, Married

(d) College, Married

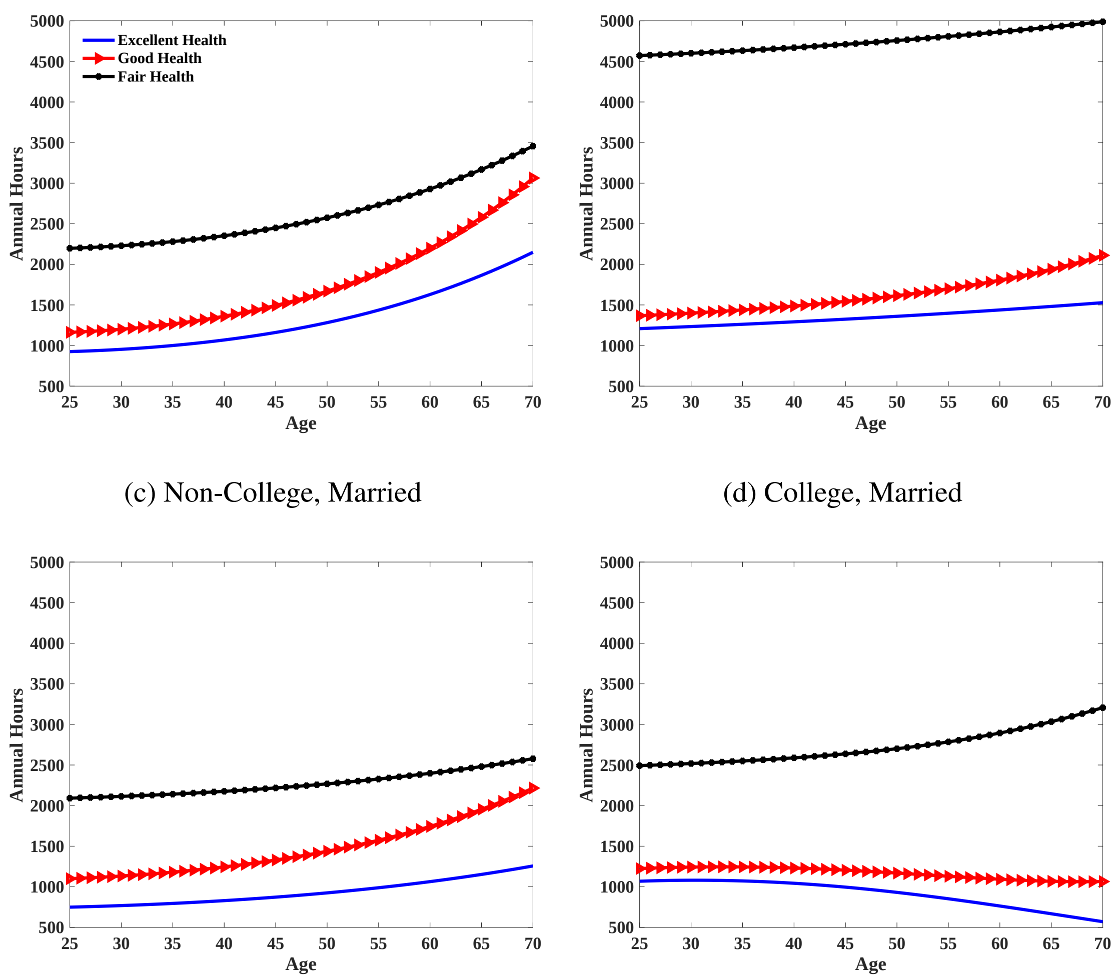


Figure C.6: Life Cycle Wage and Hours
Benchmark vs. No Unemployment Shocks Model

(a) Non-College (b) College

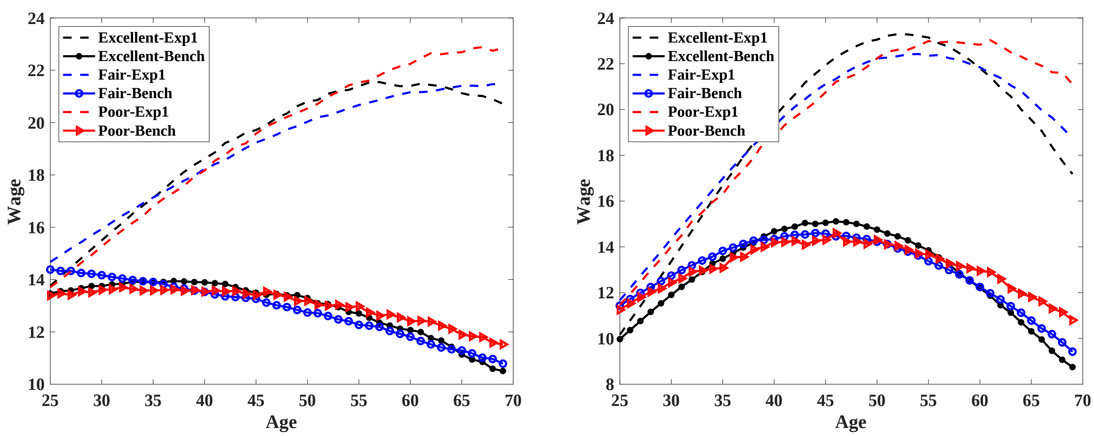
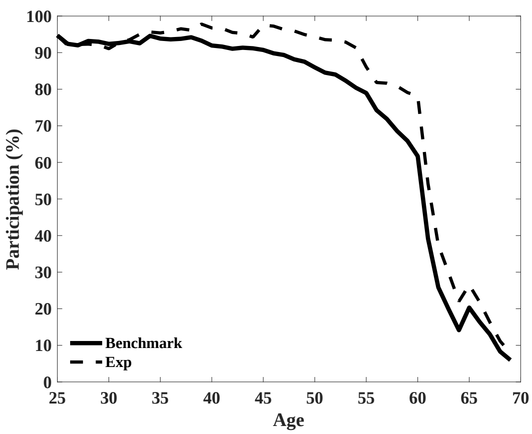
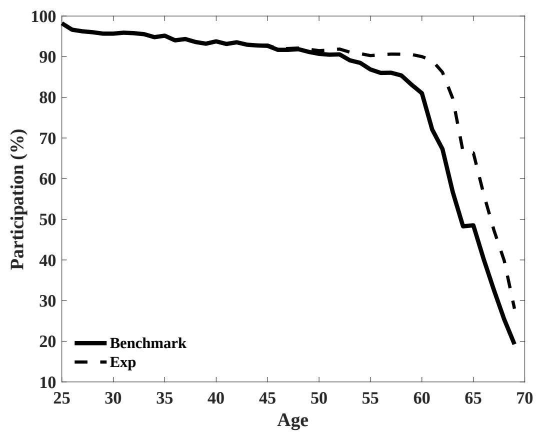


Figure C.7: No Unemployment Shocks: Participation by Education and Marriage
Men born in 1931-1935

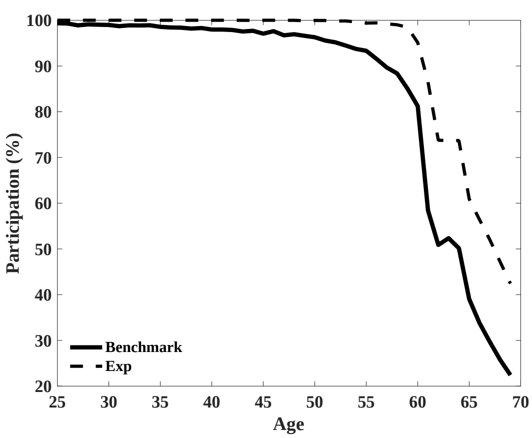
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

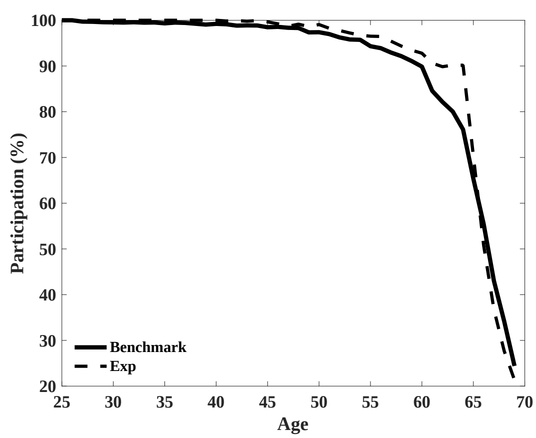
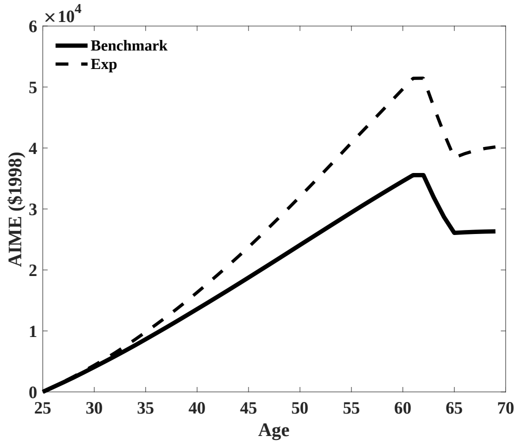
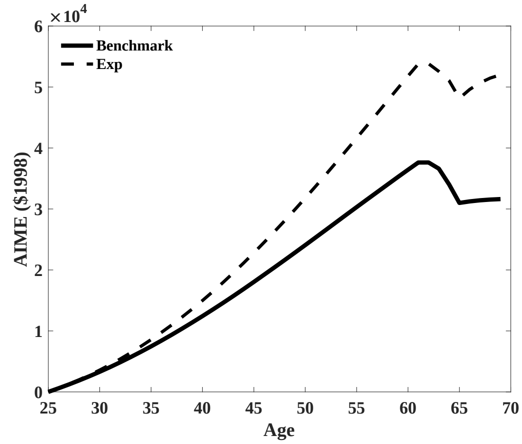


Figure C.8: No Unemployment Shocks: Social Security Wealth by Education and Marriage
Men born in 1931-1935

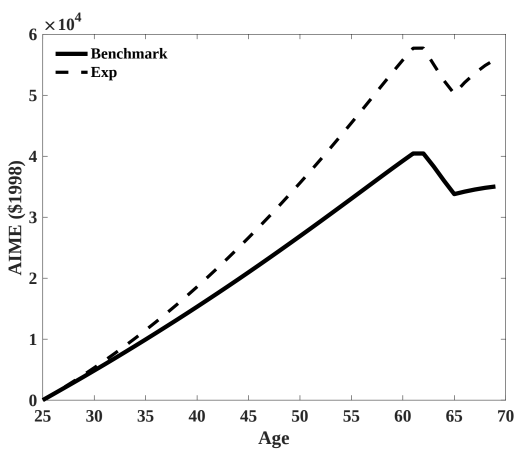
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

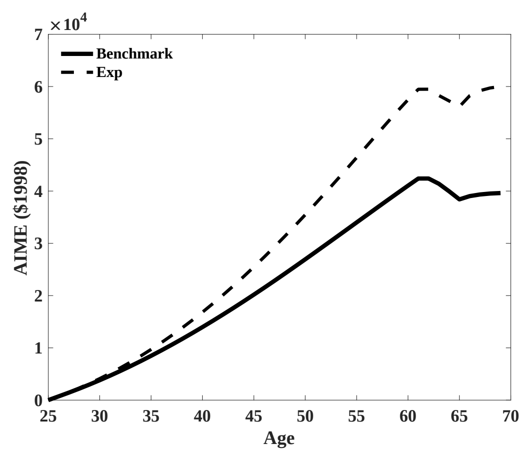
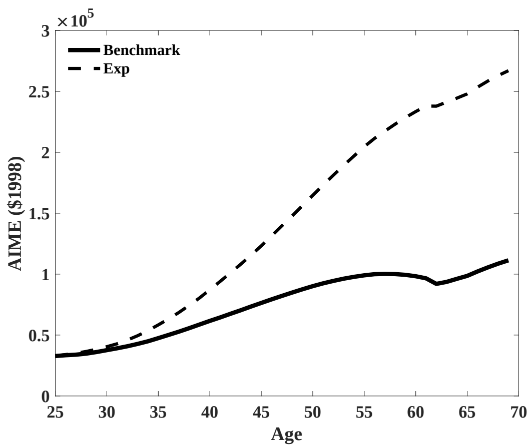
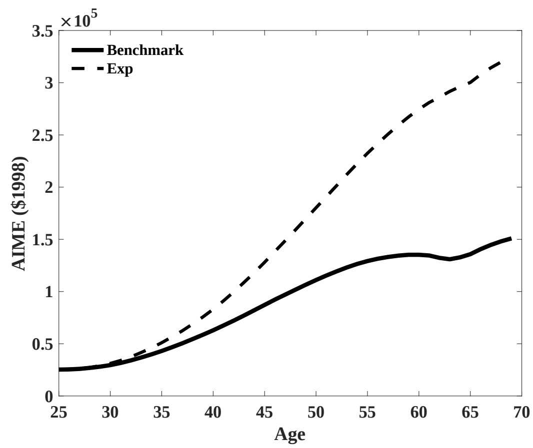


Figure C.9: No Unemployment Shocks: Wealth by Education and Marriage
Men born in 1931-1935

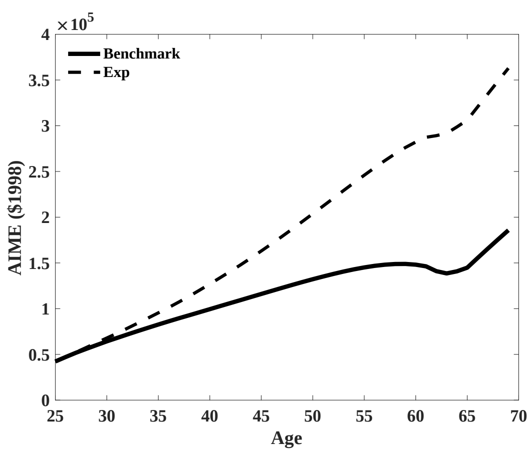
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

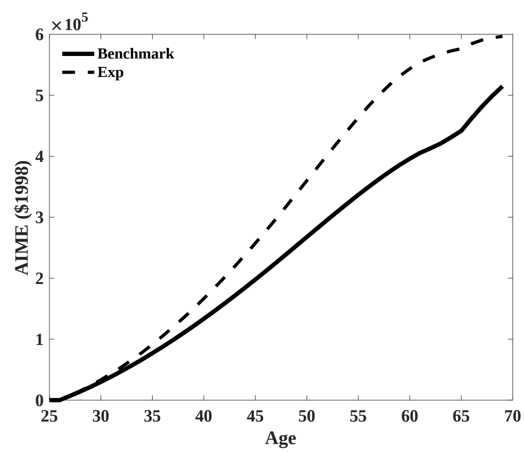
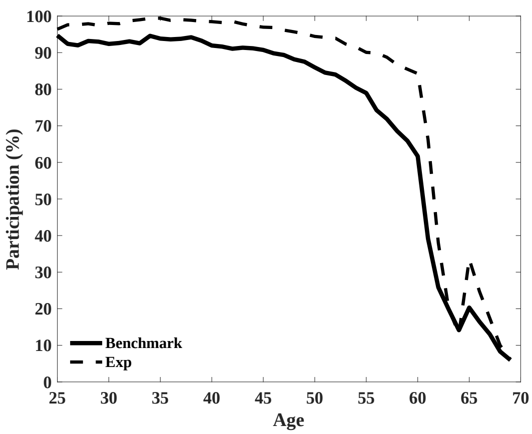
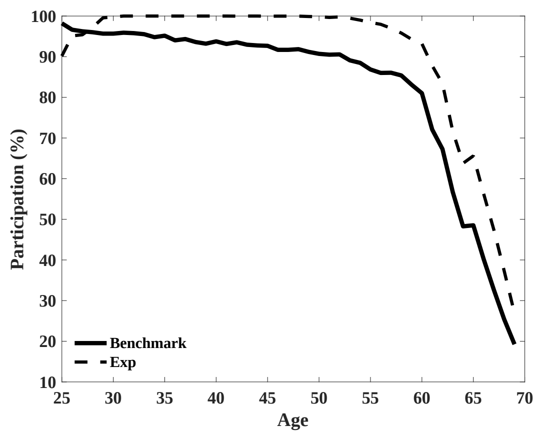


Figure C.10: No Bad Health Shocks: Participation by Education and Marriage
Men born in 1931-1935

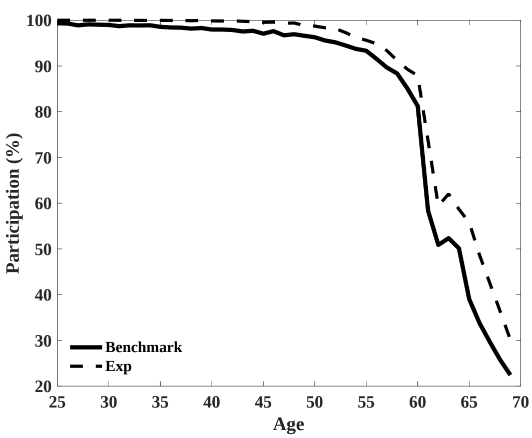
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

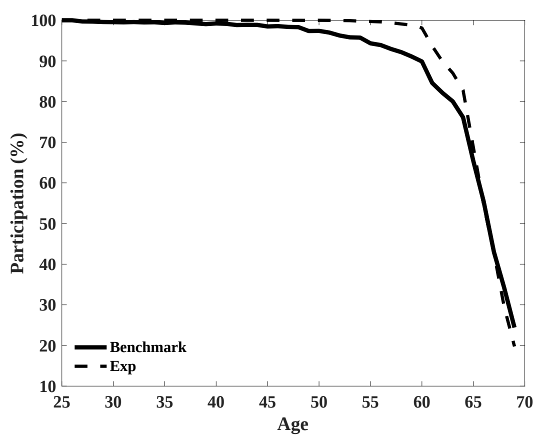
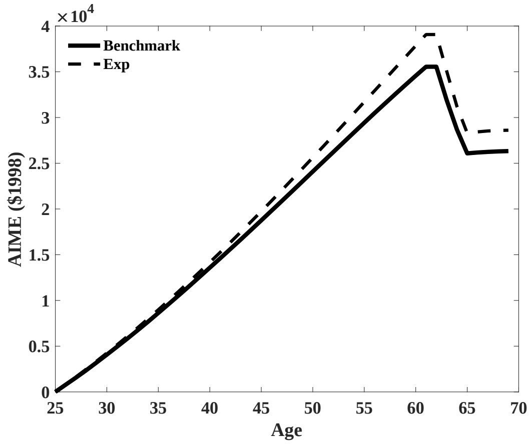
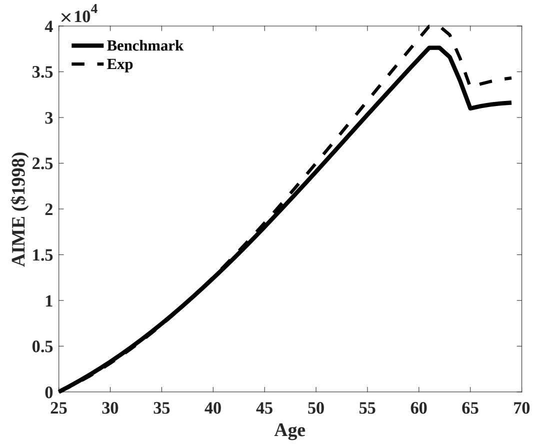


Figure C.11: No Bad Health Shocks: Social Security Wealth by Education and Marriage
Men born in 1931-1935

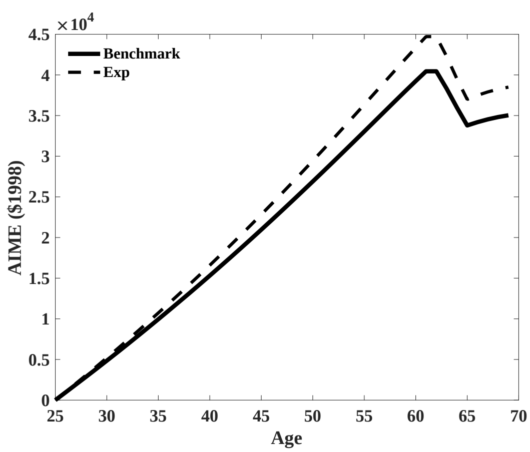
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

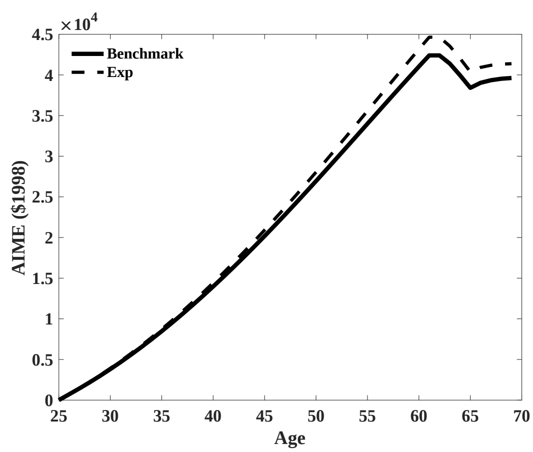
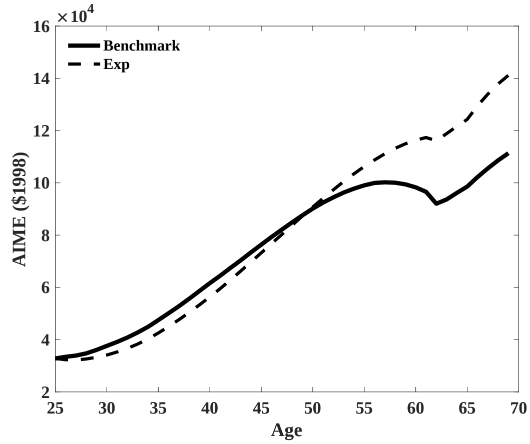
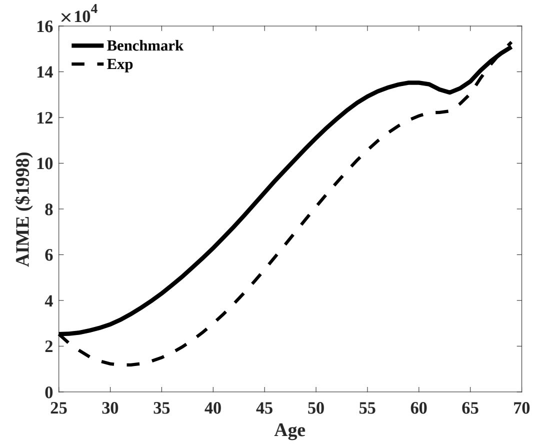


Figure C.12: No Bad Health Shocks: Wealth by Education and Marriage
Men born in 1931-1935

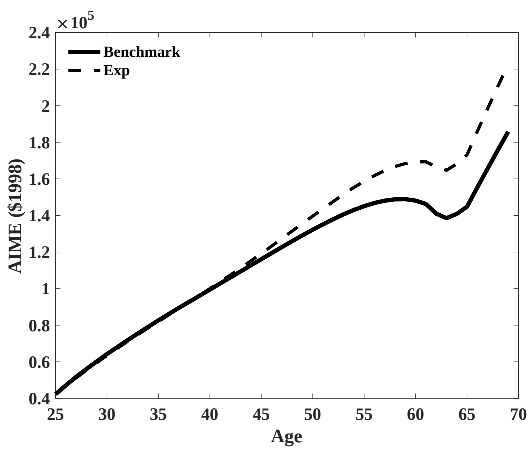
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

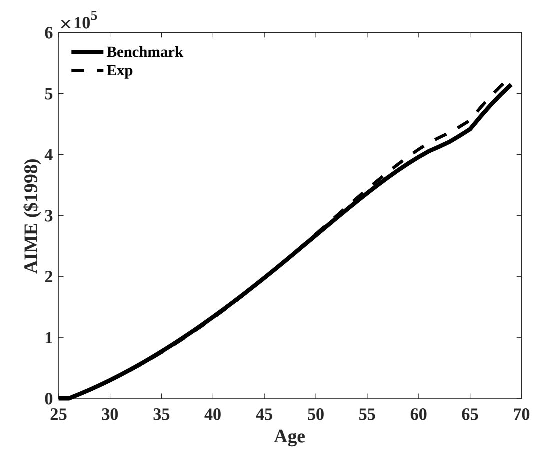
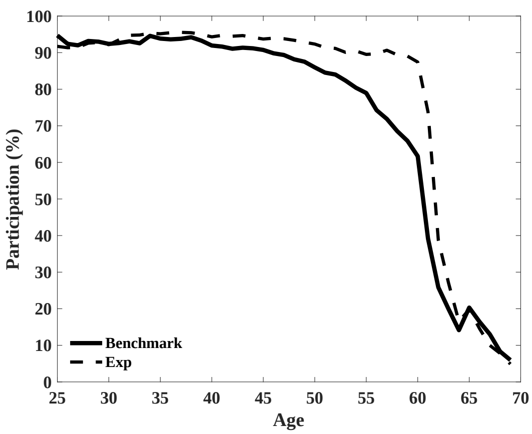
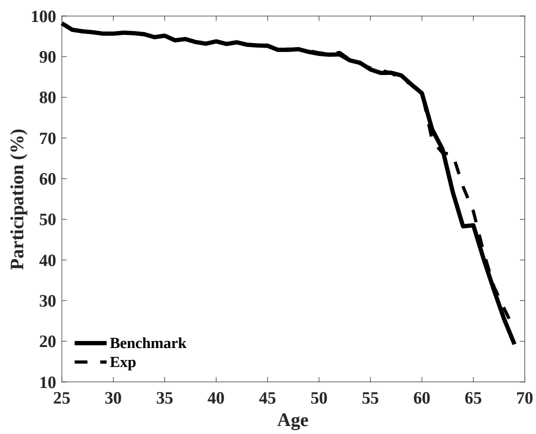


Figure C.13: No Bequest Motive: Participation by Education and Marriage
Men born in 1931-1935

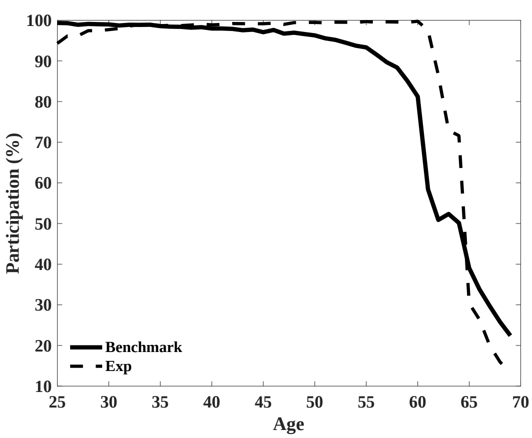
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

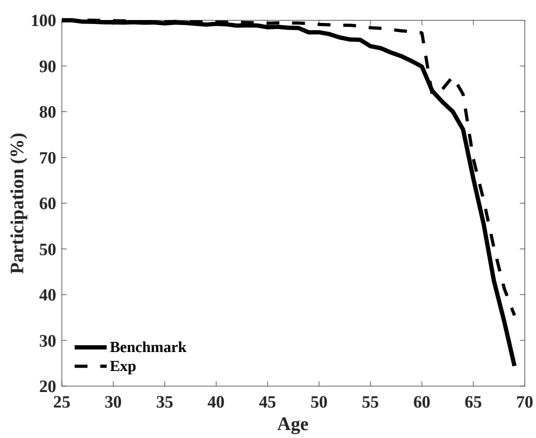
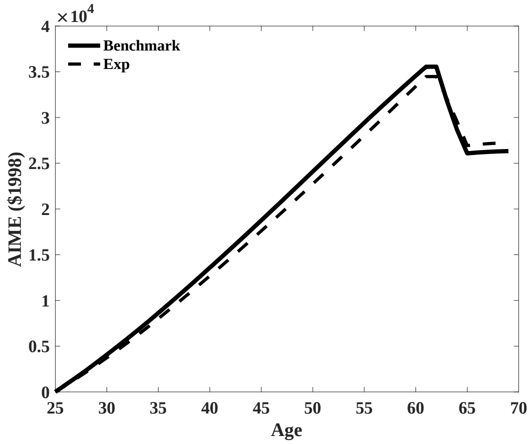
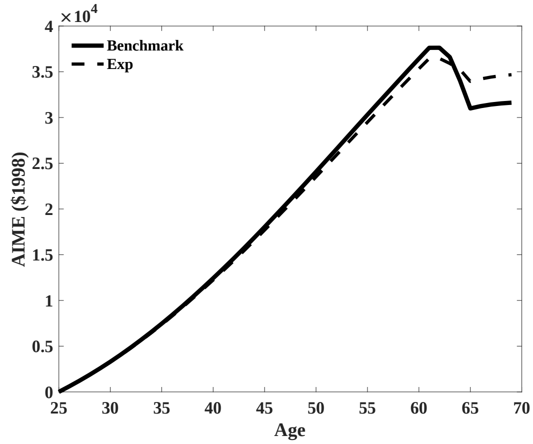


Figure C.14: No Bequest Motive: Social Security Wealth by Education and Marriage
Men born in 1931-1935

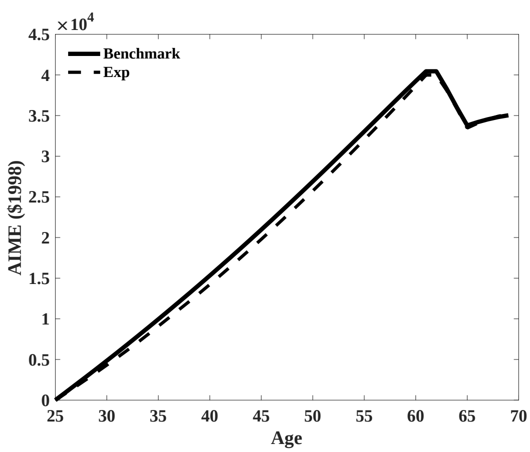
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

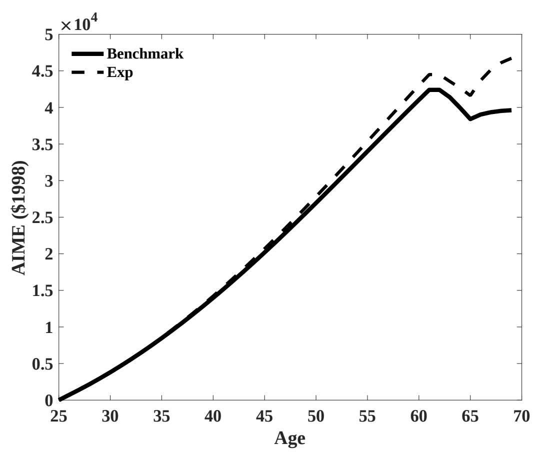
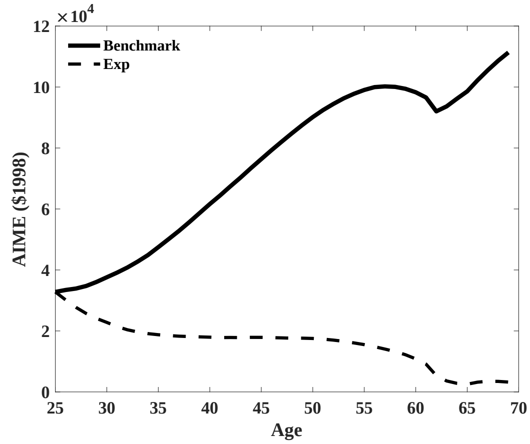
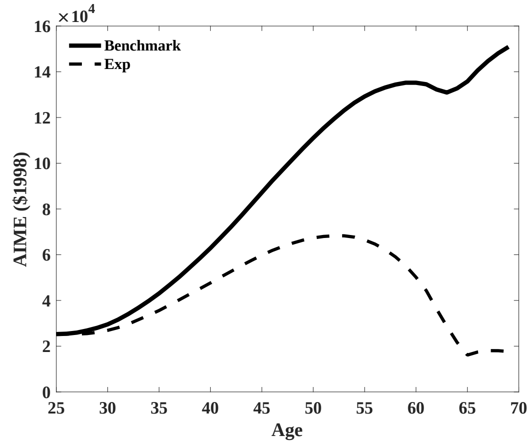


Figure C.15: No Bequest Motive: Wealth by Education and Marriage
Men born in 1931-1935

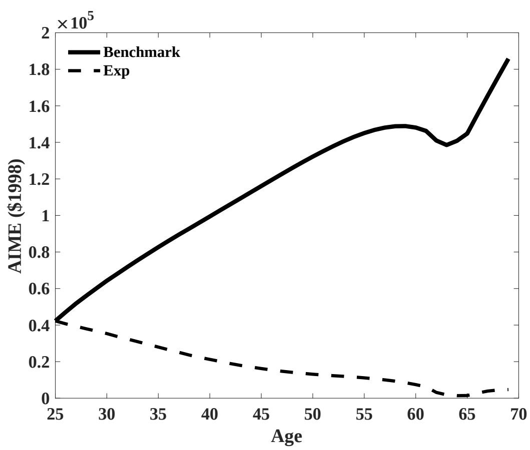
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

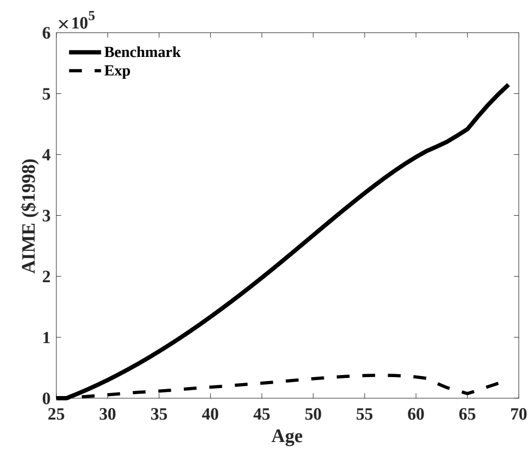
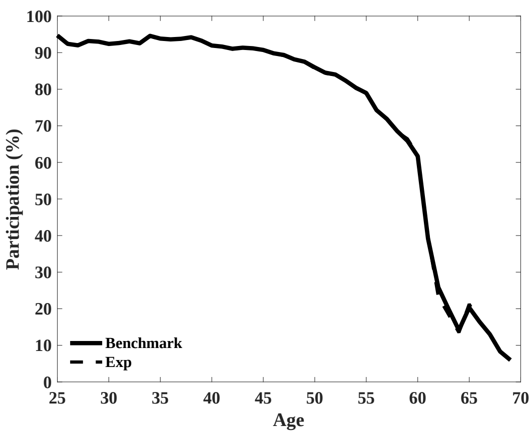
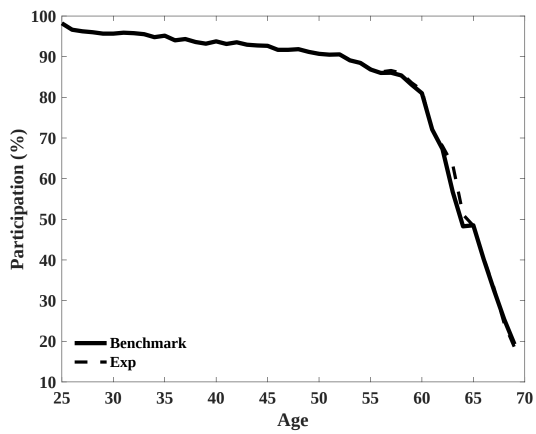


Figure C.16: No Mortality Misinformation: Participation by Education and Marriage
Men born in 1931-1935

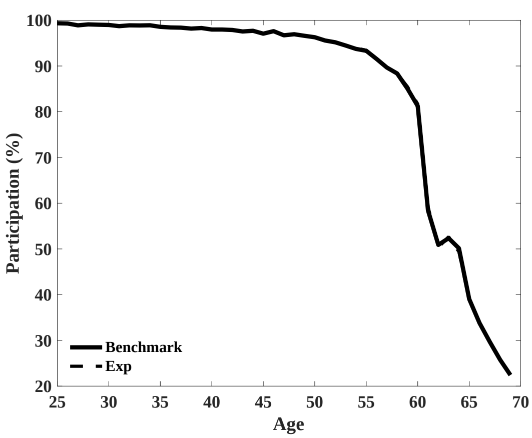
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

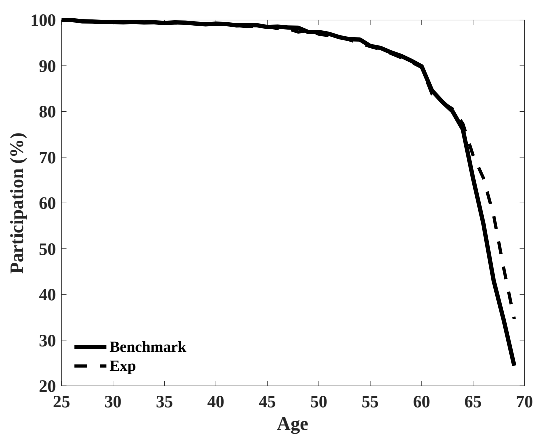
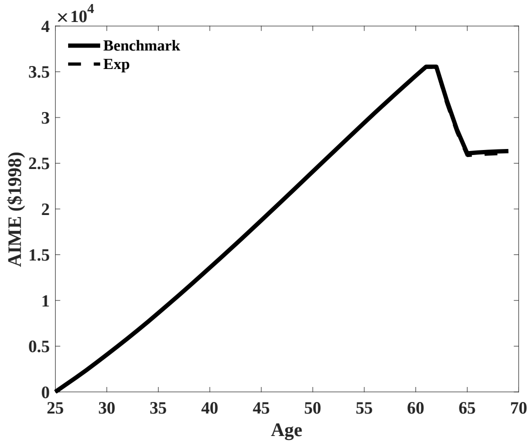
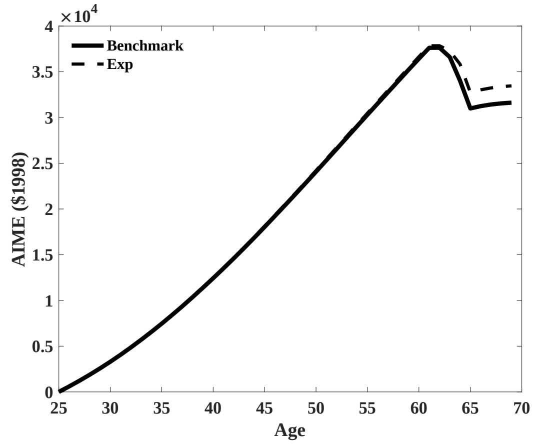


Figure C.17: No Mortality Misinformation: Social Security Wealth by Education and Marriage
Men born in 1931-1935

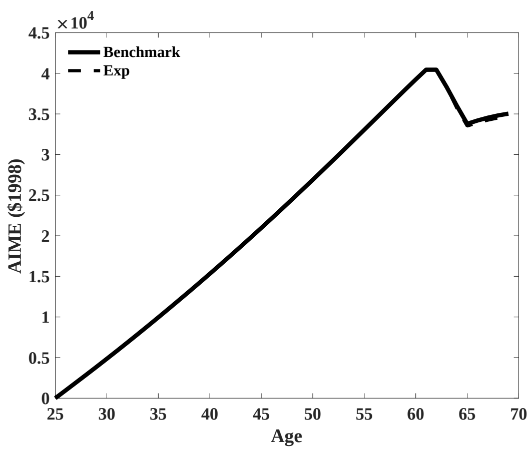
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

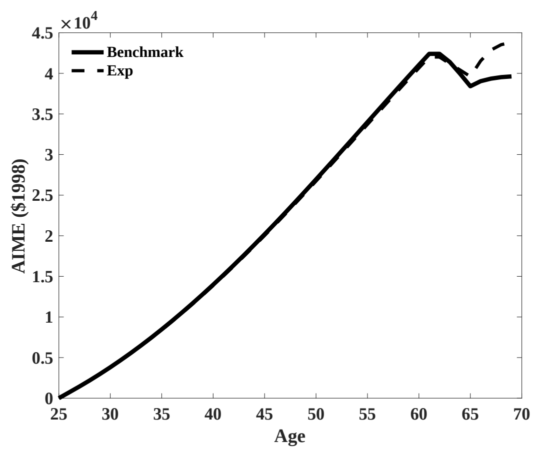
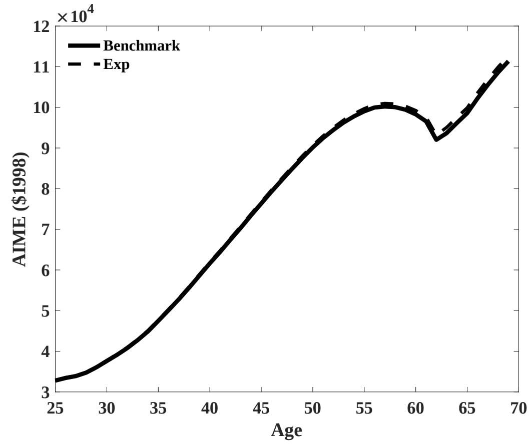
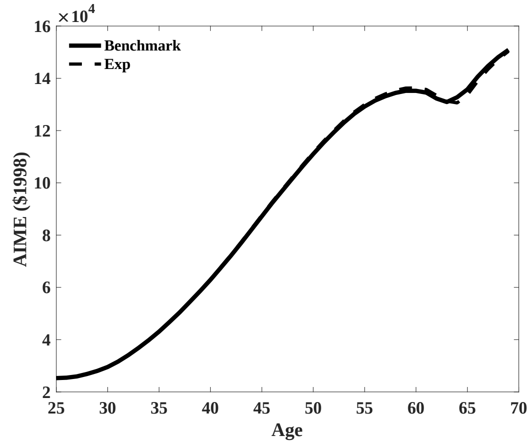


Figure C.18: No Mortality Misinformation: Wealth by Education and Marriage
Men born in 1931-1935

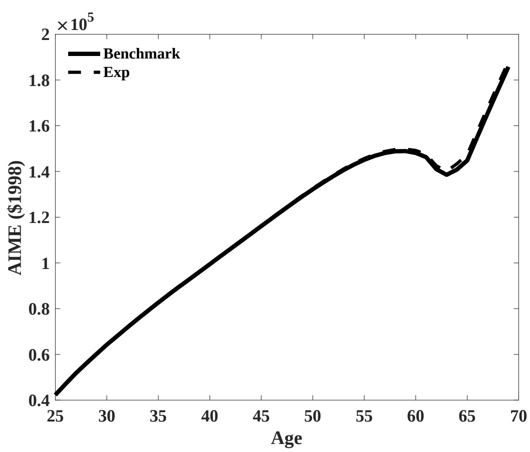
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

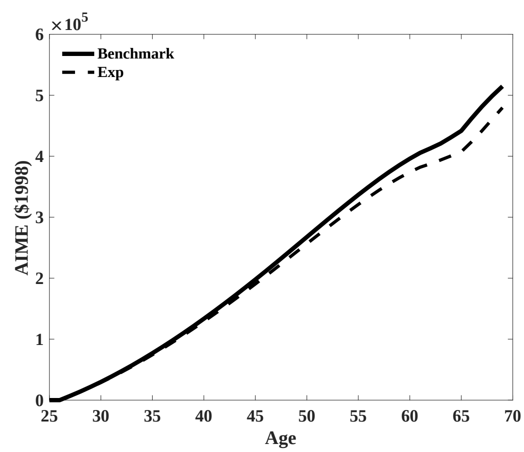
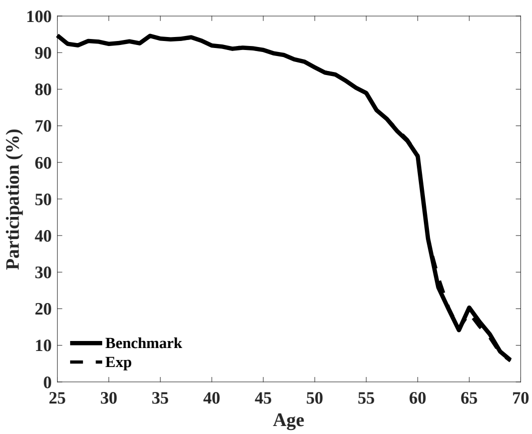
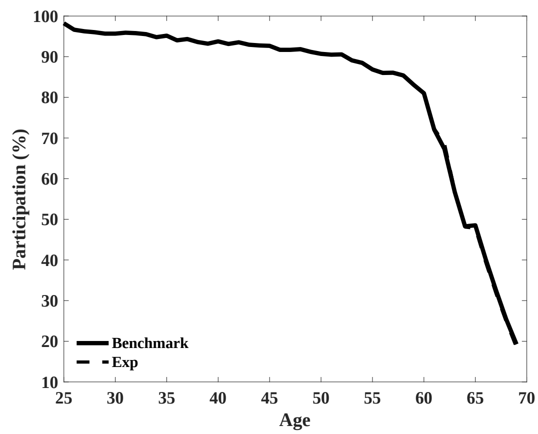


Figure C.19: SS Program Knowledge: Participation by Education and Marriage
Men born in 1931-1935

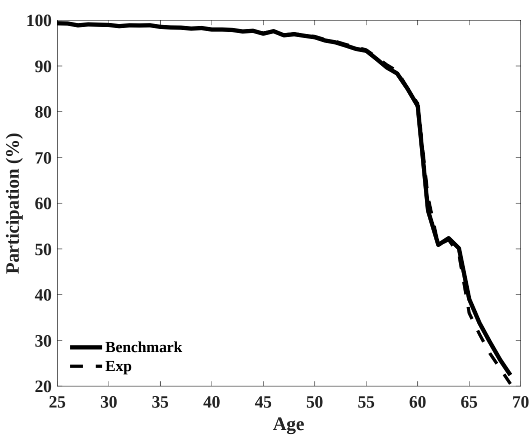
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

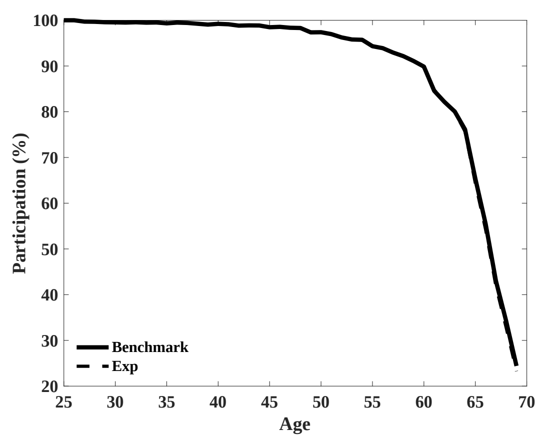
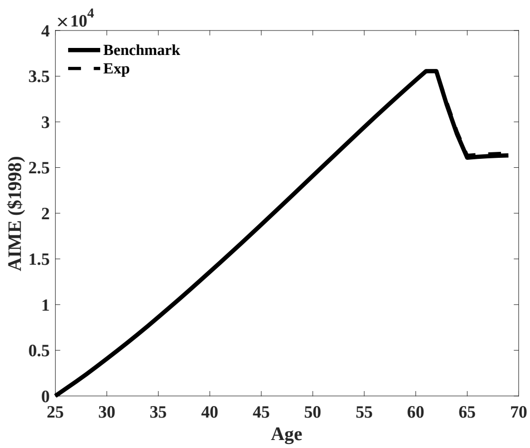
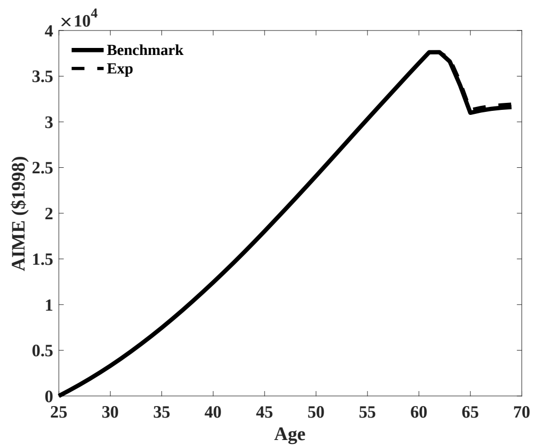


Figure C.20: SS Program Knowledge: Social Security Wealth by Education and Marriage
Men born in 1931-1935

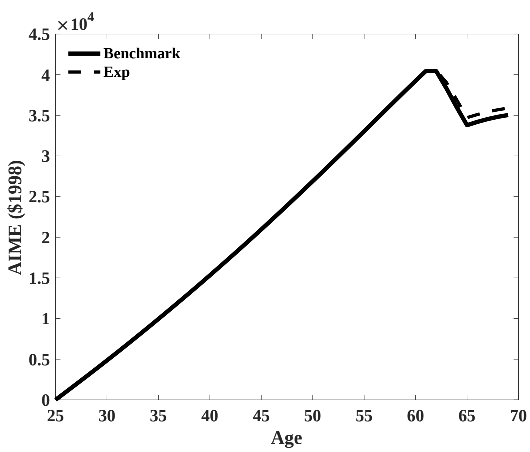
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

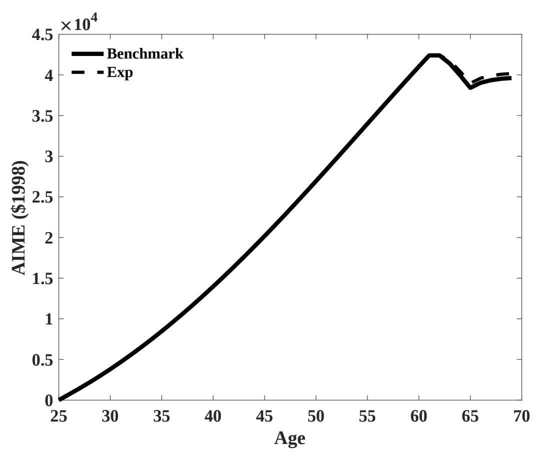


Figure C.21: SS Program Knowledge: Wealth by Education and Marriage
Men born in 1931-1935

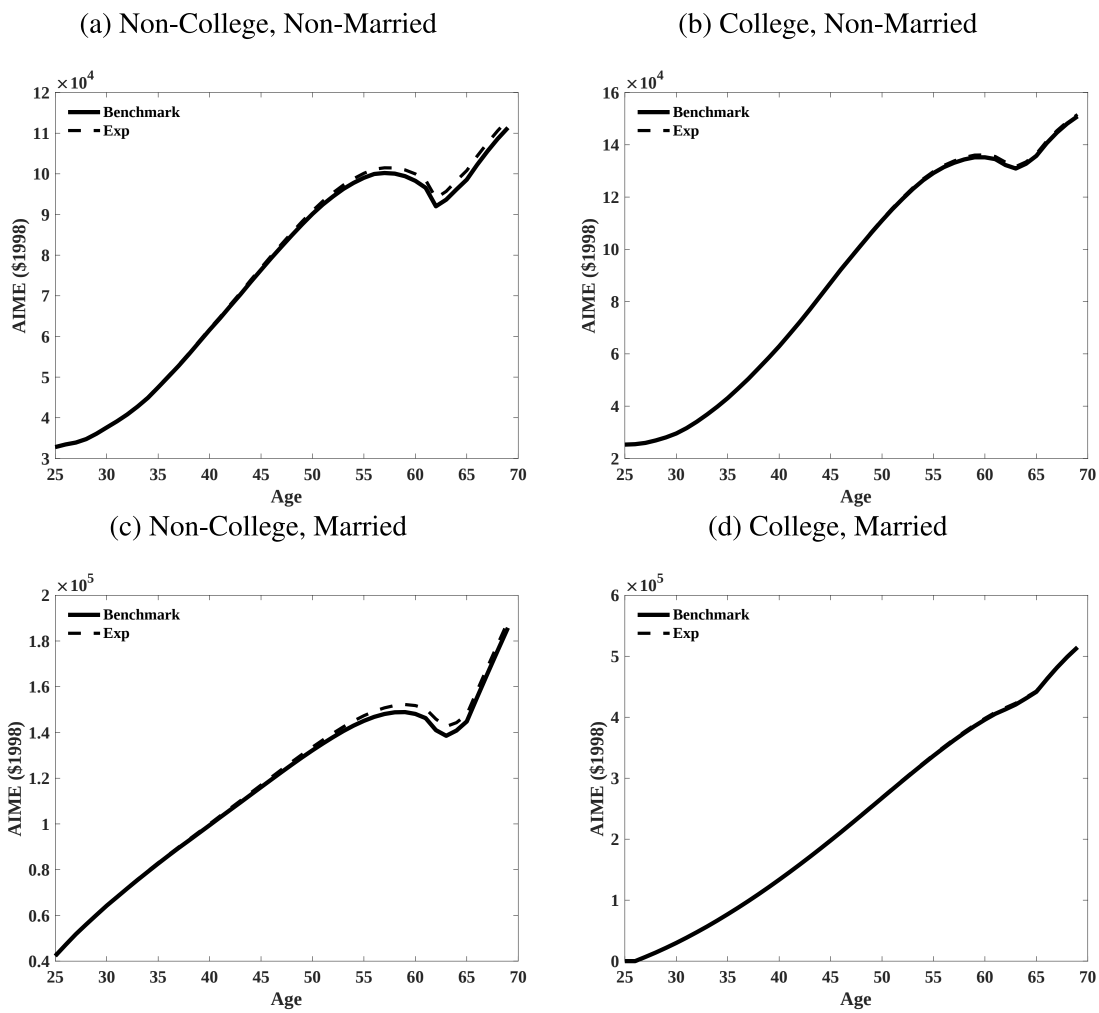
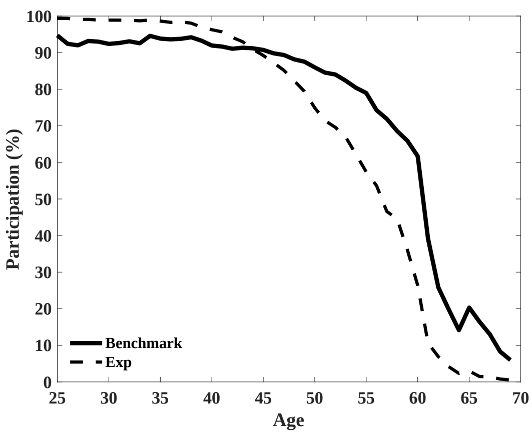
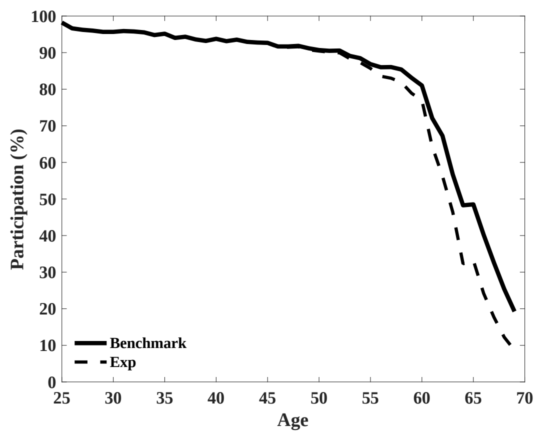


Figure C.22: Discount Rate: Participation by Education and Marriage
Men born in 1931-1935

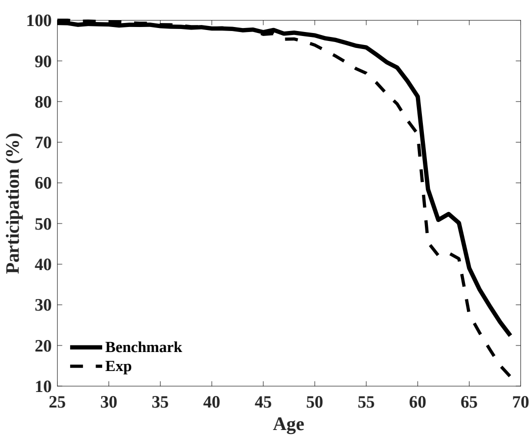
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married

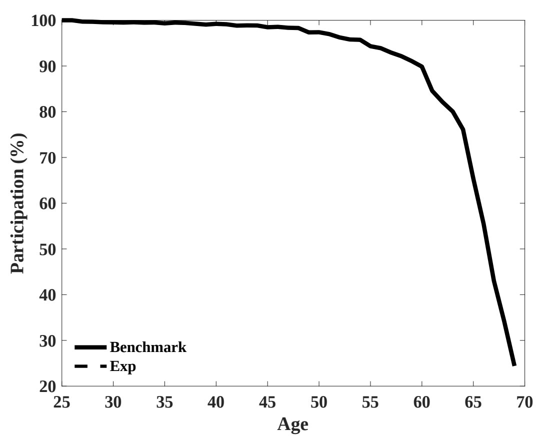


Figure C.23: Discount Rate: Social Security Wealth by Education and Marriage
Men born in 1931-1935

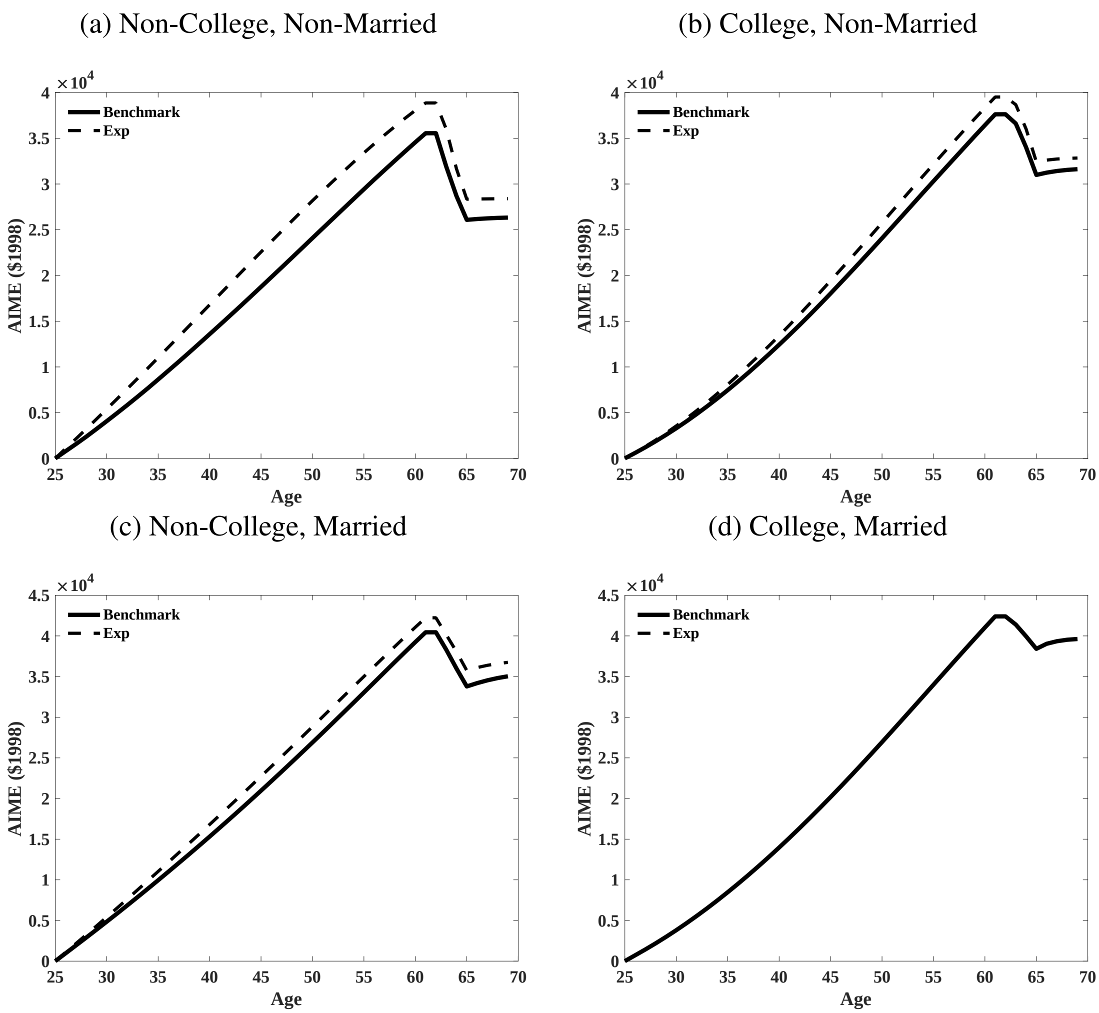
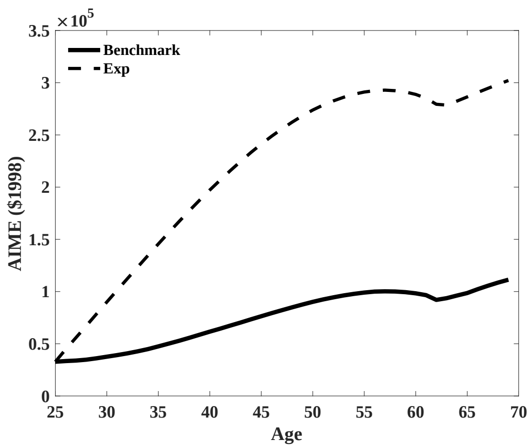
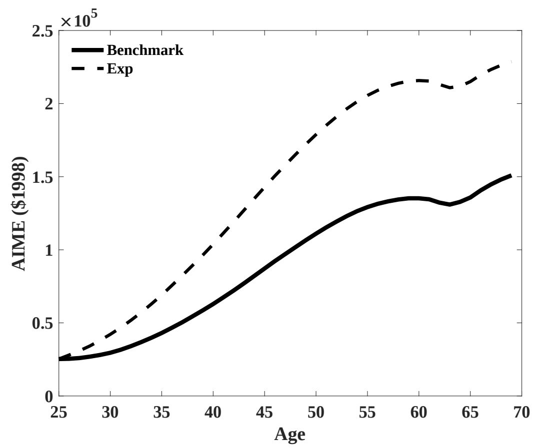


Figure C.24: Discount Rate: Wealth by Education and Marriage
Men born in 1931-1935

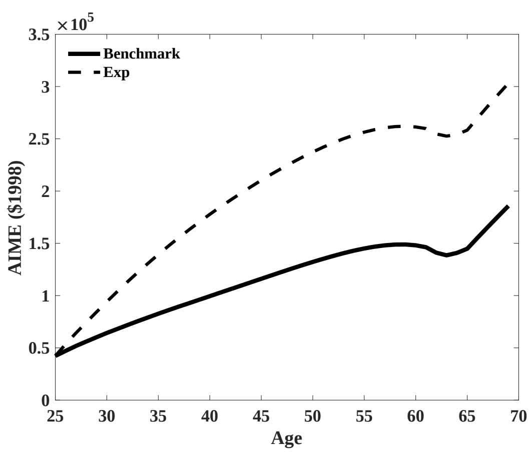
(a) Non-College, Non-Married



(b) College, Non-Married



(c) Non-College, Married



(d) College, Married